Vol. XLVIII

TABLE OF CONTENTS.

(24 pages; no inset.)

No. 24

Page.

ENGINEERING NEWS OF THE WEEK..... 480

LEADING ARTICLES:
Power Development on the Canadian Side of Niagara Falls (illustrated)..Orrin E. Dunlap. 490
Suggested Improvement of the Sewer System of Chicago..... 491
Tank Cars with Riveted Truss Frames (illustrated) 492
The Metric System.....F. A. Halsey, M. Am. Soc. M. E. 492
Concrete Pile Foundations at Aurora, Ill. (illustrated) 495
Superheated Steam .....E. H. Foster, M. Am. Soc. M. E. 495
Rotary Pumps (illustrated).....John T. Wilkin, M. Am. Soc. M. E. 496
Monier Concrete-Steel Storage Tanks for Portland Cement; Illinois Steel Co. (illustrated).. 498
Bituminous Macadam Pavement on Main St., Everett, Mass..... 499
Malleable Cast Iron.....H. E. Diller. 499
Recent British Practice in Refuse Disposal Furnaces 505
The Use of a Surveying Instrument in Machine Shop Practice (illustrated).....
Charles C. Tyler, M. Am. Soc. M. E. 503
Grade Reduction on the Minneapolis & St. Louis Ry. and the Northern Pacific Ry..... 505
Centrifugal Machines and Their Uses (illustrated)..Bartholomew Viola, M. Am. Soc. M. E. 506
A Prospector's "Grub-Stake"..... 507
The New York Meeting of the American Society of Mechanical Engineers..... 509
The Improvement of Interior Lighting (illustrated) 510
The 25th Anniversary Banquet of the Engineers' Club of Philadelphia..... 511

EDITORIAL COMMENT.—Ice on the Third Rail—Giving the Degree of "Doctor of Engineering" for Post-Graduate Research Work—An Investigation of the Advance in Freight Rates—An Opportunity for Good Roads Advocates—Coöperation and Federation of Engineering Societies 500

EDITORIALS:
The Amortization of a Contractor's Plant and Allowance for Profits..... 500
Against the Metric System..... 501

LETTERS TO THE EDITOR.—Standard Crowns for Street Pavements in Omaha: Andrew Rosewater—Temperature Stresses in Aluminum Transmission Wires: R. D. Johnson—The New York Canal Improvement: John A. Collier Wright—Diagram for Unit Stresses in Steel Columns (illustrated): H. M. Knapp—The Cost of Mine Timbering; a Criticism: B. C. Yates; Bernard MacDonald—The Viewpoints of the Outdoor Man and the Indoor Man: G. L. F.....501, 503

THE LARGEST TURBINES IN THE WORLD have been ordered by the Canadian Niagara Power Co. from Escher, Wyss & Co., of Zürich, Switzerland. They will be of 10,000 HP. each, and three such units have been ordered for the present. It will be recalled that the same manufacturers designed the turbines for the two existing Niagara (upper) power stations on the American side, ten of 5,000 HP. each in the old station, and ten of 5,500 HP. each in the new station. These turbines were built almost entirely in America, to complete working drawings as furnished by Escher, Wyss & Co.; only the vane-wheels themselves and some of the turbine governors were built in Switzerland. The import duty conditions which were responsible for this arrangement do not control in the present case, and the entire construction work on the turbines will be done in Zürich. These new Canadian turbines will work under conditions closely the same as on the American side, and their construction, apart from the difference in size, will follow along the same lines adopted for the others.

THE PRELIMINARY REPORT on the income account of railways in the United States for the year ending June 30, 1902, prepared by the statistician to the Interstate Commerce Commission, contains returns of railway companies operating 195,945 miles of line, or probably 98% of the mileage that will be covered in the full report on the statistics of railways for that year. The passenger earnings of the railways represented were $472,429,165, and the freight earnings $1,200,884,603. Including these and other earnings from operation the gross earnings amounted to $1,711,754,200, or $8,736 per mile of line, and operating expenses to $1,106,137,405, or $5,645 per mile of line, showing that net earnings were $605,616,795, or $3,091 per mile. The net earnings of the roads, it appears, were $51,395,421 greater than those which were received during the previous year. The total income of the roads covered by this advance report, including $82,714,492 derived from investments and miscellaneous sources, was $688,331,287. Deductions from income aggregated $458,459,961. This amount comprised interest on funded debt, rent of leased lines, betterments charged to income, taxes ($49,426,675), and various minor expenditures. The report shows that dividends declared on stocks amounted to $150,685,959, and it appears from comparative figures that the dividends of essentially the same roads were $29,834,630 greater for the last fiscal year than for 1901. The surplus from the operations of the roads for which returns are compiled was $79,185,367. The complete report for the year ending June 30, 1901, gave a surplus of $84,764,782. It should be stated that this report relates to operating roads only, and consequently does not include dividends paid by leased lines from the income they receive as rental. In the year 1901 the dividends of all the railway companies aggregated $156,735,784, this amount including about $35,000,000 paid by the leased lines.

THE PACIFIC COAST RAILWAY CLUB'S competition for a paper dealing with railways, announced in our issue of Nov. 27, has been extended in time so that papers may be received until February 1, 1903. The other conditions remain as given in our previous note. The secretary of the club is Mr. C. C. Borton, 1213 Twelfth St., Oakland, Cal.

MECHANICAL DRAFT for the boiler equipment of the St. Louis Exposition power plant will have the unusual feature of combining forced draft and induced draft. The plant will comprise 26 boilers of 200 HP. each. There will be four forced draft fans of the full housing type and 160 ins. in diameter. After the gases pass through the boilers they will enter two induced draft fans, 230 ins. or over 19 ft. in diameter. The fans and engines for the above equipment will be furnished by the Buffalo Forge Co.

DOUBLE-CURRENT GENERATORS are in use in the power house of the Seoul Electric Co., in Korea, which supplies current for an electric railway 12 miles in length and also for about 1,400 incandescent lamps. Two 120-KW. generators made by the Westinghouse Co. are in use and they furnish at the same time direct current at 550 volts to the railway circuits and high tension alternating current for lighting. The plant was installed under direction of a Japanese engineer who graduated from the Massachusetts Institute of Technology.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was the wreck of a fast passenger train on the Intercolonial Ry., at Belmont, near Truro, Nova Scotia, on Dec. 6. The train, which was not due to stop at Belmont, went by the station at full speed, when the locomotive left the rails, due to a broken cowcatcher, and piled the coaches in a heap. The ordinary coaches, nearest the engine, were smashed; the engine-runner and six passengers were killed and several other persons were injured.——Some other fatal railway accidents of the week past are worth mention: On Dec. 3 a passenger train on the Cincinnati, New Orleans & Texas Pacific Ry. ran into an empty car that had blown off a siding onto the main track, at Sunbright, Tenn. The wreck of the train caught fire, and three persons were killed in the wreck and fire, it is reported. On Dec. 2 a freight train on the West Virginia Central Ry. ran away down a mountain grade and was wrecked at a reverse curve. The engineer was killed.

ANOTHER WOODEN WATER TANK in railway service has failed, this one being in the yards of the New York, New Haven & Hartford Railroad, at Providence, R. I. The tank had a capacity of about 50,000 gallons, and the failure occurred on Nov. 20, while some repairs were being made, it is said, to the steel hoops. The workmen were thrown to some distance by the escaping water, but were not killed. From a view published in the Providence "Telegram" of Nov. 21, it appears that the bottom of the tank and the whole of the supporting columns were left in position.

OVERHAULING IRON TROLLEY POLES has been carried out by the Columbus (O.) Railway Co., with the view of retarding rust, which was especially destructive at the ground line. Excavation showed the poles to be deeply pitted at this point of maximum stress and the destruction of the poles was feared. After laying the poles bare a foot or more below the surface of the ground, and then using a sand blast until the exposed metal was thoroughly cleaned, the fresh surface was painted. Later the lower portion of the pole was encased in cement mortar, neatly troweled off a little above the surface line so as to shed water. The entire pole was then painted.

THE PORTSMOUTH NAVY YARD DRY-DOCK has been cracked by the blasting done at Henderson's Point, says the Boston "Traveller." The Massachusetts Construction Co. is engaged in blasting away the point, which is at the extreme end of Seavey's Island, and less than one-quarter mile from the yard. The rock formation is continuous, and the site for the dry-dock was excavated in this rock. The shock of the heavy charges used is said to have cracked in two granite blocks weighing nearly a ton each ;and the contractors have been directed to use lighter charges. No material damage, however, is done to the dry-dock itself.

THE NEWARK GARBAGE AND REFUSE collection and disposal contract has finally been awarded to Mr. Benjamin Meyer, of Newark, who, it is understood, will erect an Arnold-Edgerton garbage reduction plant. Under the contract, garbage, ashes, paper and other light refuse are to be collected separately.

SEWERAGE BIDS AT NEW ORLEANS will be received on Feb. 2, instead of Feb. 23, 1903. The latter date was given by mistake in a recent issue of this journal.

THE ANNUAL REPORT OF THE SECRETARY OF War, just presented to Congress, contains a number of important recommendations. Chief among these are the following: The regular army to be maintained at 60,000 men; a General Staff to be created, with the title of Chief of Staff substituted for Commanding General; the further education of young officers now in the army and not graduated from West Point; the improvement of State Militia conditions; the repeal of the anti-canteen law, as the result of experience with the abolition of the sale of beer and light wines in barracks and under military supervision. Under the head of Coast Defences, Secretary Root reports great progress and says the plans of 1888 are half carried out. In the period 1888-1896 the sum of $3,521,000 was expended for fortifications, while in the period 1896-1901 the sum of $22,236,000 has been used; in the same period the expenditure for guns and carriages rose from $8,100,000 to $24,193,000. The total appropriations for the army in 1902 were $116,000,000, and of this $78,000,000 has been expended. Secretary Root says that of the 17,343 immigrants entering the Philippines in 1901, 15,312 were Americans.

PRIZES FOR GOOD WORK on sewer maintenance in the borough of Brooklyn, New York city, have been given to foremen and workmen of late as a reward for good service.

THE ST. LOUIS-CHICAGO CONTROVERSY over the pollution of the water supply of the former city by the discharge of the sewage of Chicago through the drainage canal will probably drag along for a year or so more, it having been arranged that each side shall have three months to present evidence, then 15 days for rebuttal of the evidence put in by the other side. A special commissioner will take the evidence.

PLANS FOR BEAUTIFYING NEW YORK CITY were discussed at a recent conference of representatives of business, engineering, architectural and other art societies. Among those present were: J. J. R. Croes, of the American Society of Civil Engineers; Prof. A. D. F. Hamlin, of Columbia University, and Hon. John De Witt Warner, President of the Municipal Art Society. Another conference will soon be held.

A NEW TERMINAL STATION at Kansas City, Mo., is proposed by the Union Depot, Bridge & Terminal Co. The city now has two large stations, the largest of which has an old and inconvenient building and track facilities entirely inadequate for the traffic. This is owned by a company formed by representatives of several railways, and these railways cannot agree among themselves as to the character of improvements needed. The new company has acquired large tracts of land on the north side of the city, on both sides of the river, and also owns the grant for the Winner bridge, which will connect these properties. This bridge was projected several years ago, and the piers were built, but no superstructure was ever erected. The new company has completed plans for the superstructure and expects to build the bridge very shortly. It will be a double-deck structure for railways, roadway and electric railway, and will have a very heavy drawspan. The passenger terminal, freight terminals, grain elevators, stock yards, etc., are to be located on the company's land, but no definite plans have yet been made for anything but the Missouri River bridge. Mr. George H. Ross is President of the company, and Mr. F. Moore is Chief Engineer.

MUNICIPAL IMPROVEMENTS AT IQUITOS, PERU, are said to have been undertaken by the Peruvian Government. Mr. J. C. James, an American engineer, represents New York capitalists who have paving and sewer contracts at Iquitos, a city of 10,000 inhabitants. Negotiations are being made for similar contracts at Manaos, a city of 40,000 people, situated about 1,000 miles up the Amazon.

POWER DEVELOPMENT ON THE CANADIAN SIDE OF NIAGARA FALLS.

By Orrin E. Dunlap.*

While there is no cessation of operations on the New York side, the most active industrial development at Niagara is at present largely centered on the Canadian side of the river. Here two companies are engaged in immense projects for the development of a large portion of the energy of the stream. In some respects the scene on the Canadian side rivals anything ever observed on the New York side, where the Niagara Falls Power Co. has erected two wonderful installations. In the past many who visited Niagara may have gained the impression that the development of Niagara power was to be a one-sided affair, that is, all on one side of the river, but the work now in progress gives full assurance that the Dominion of Canada is to profit to an immense degree by the diversion of a portion of the river's flow to develop power for the benefit of its industries.

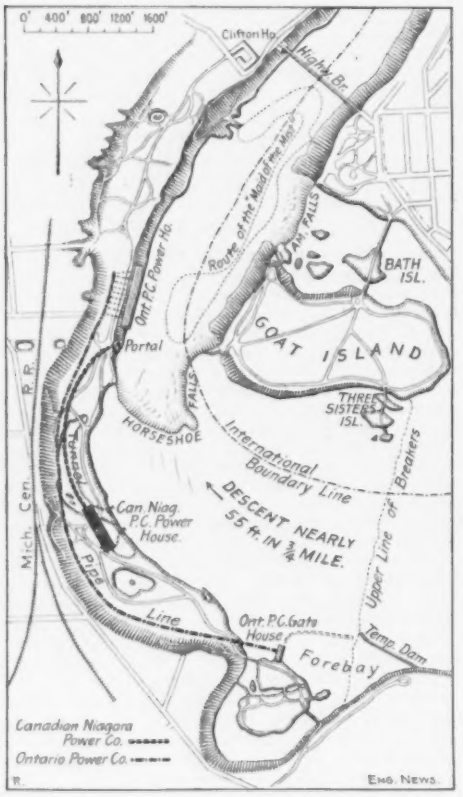

Fig. 1. Map of Canadian Side of Niagara Falls, Showing Location of Power Development Work.

THE CANADIAN NIAGARA POWER COMPANY'S WORK.

This company is controlled by the same capital as the Niagara Falls Power Co., and it will profit by the experience of the latter company in its development on the other side. Its method of development is identically the same. It is building a great wheel-pit, which is to be connected to the lower river by means of a tunnel tailrace. The plan of the company is to make this wheel-pit eventually 480 ft. long, but at present a section 266 ft. long is being built. It is 21 ft. wide and will have a depth of 170 ft. The present depth is about 110 ft., the rate of excavation being about 12 ft. a month. In the sinking of this great slot the engineers have found practically the same conditions as in the construction of the two pits on the New York side. Water is met a little nearer the surface, but hardly in such large quantity, and with the exception of finding a blue limestone not found in the American pits, the rock strata are about the same. The sides of the pit are channelled, and up to this time the contractors have been using derricks to hoist the rock from the pit.

In front of the wheel-pit a large forebay is being built. It will be the full length of the pit, but will narrow down to a canal-like section at a point where it will be crossed by the tracks of the Niagara Falls Park & River Ry. and a driveway, after passing which point it will again flare out to a width of about 400 ft. From the forebay at the north end of the wheel-pit a canal 16 ft. wide and 500 ft. long will be built to the river, and this will be used as an ice run. Gates will regulate the flow.

The contract for the wheel-pit and farebay construction is in the hands of Dawson & Riley, of St. Catharine's, Ont. The bridge that will span the canal part of the forebay will be a stone arch of great beauty. It will have a length of 250 ft., divided into five spans, while its width will be about 60 ft., affording room for a driveway in addition to the trolley tracks. Messrs. Mumford & Lowery have the bridge contract.

The tunnel that will connect the wheel-pit with the lower river is 2,200 ft. long, 25 ft. high and 18 ft. wide inside the lining at the spring line. Its height is thus 4 ft. greater than the tunnel of the Niagara Falls Power Co., but this latter tunnel has a length of 7,436½ ft. In the construction of the tunnel a shaft 10 × 16 ft. was sunk midway between the wheel-pit and the portal. The heading has been driven, and men are now removing the bottom bench, having taken out about 1,200 ft. of it.

The intention was to line the Canadian tunnel with brick similar to the power tunnels previously built, but owing to a scarcity of brick it has been found necessary to adopt concrete for a portion of the work from the spring line down. This will save the use of 3,000,000 brick, but the concrete will be faced with vitrified brick, and about 1,250,000 brick will be used in the arch. The brick are obtained in Beamsville, Ont. About 20,000 barrels of Lehigh cement, furnished by the Thorne Cement Co., of Buffalo, will be used in the concrete work.

The portal of the tunnel is located close up to the Horshoe Fall, and the stream from it will discharge at its base. The masonry about the portal will be massive in order to withstand the conditions of all seasons. Its location is such that an immense amount of ice will form about it in winter time. Sixty car loads of granite from near Quebec and 200 car loads from Queenston will enter into the work. In timbering the tunnel over 2,000,000 ft. of timber was used. This was supplied by the C. Haeberle mills, of Niagara Falls. Anthony C. Douglass, of Niagara Falls, N. Y., is the contractor on the tunnel work. His plant consists of two compound duplex Ingersoll air compressors of 125 HP. each, operated by a 400 HP. electric motor, the current for which is transmitted from the New York side. He also has 12 Ingersoll drills, two Lidgerwood double drum hoists, one Otis elevator lift and a rock crusher. The plant of Dawson & Riley, contractors on the wheel-pit, canal and forebay consists of 750 HP. boiler capacity, two compound Rand air compressors, each of 250 HP.; eight Sullivan [illegible] ing machines, eight Ingersoll drills and two [illegible] ders, and two 10-ton Brown locomotive [illegible]

The plant of the Canadian Niagara Power Company will be notable from the fact that the unit of development will be 10,000 HP. The current will be generated at a voltage of 12,000 [illegible] phase, 25 cycles, the generators to make 250 revolutions per minute. This voltage of 12,000 will result in economy in the transmission to the industrial plants using the power, for all of the manufacturing establishments and consumers of power must be located outside of the limits of Victoria Park. Toronto is also expecting to profit by the development, and for transmission to these distances a potential will be used of 40,000 to 60,000 volts.

ONTARIO POWER COMPANY'S DEVELOPMENT.

The second company that is building on the Canadian side is the Ontario Power Co., of which John J. Albright, of Buffalo, is president. For their development this company has adopted a plan quite similar to that of the Niagara Falls Hydraulic Power & Manufacturing Co. on the New York side. It will take its water supply from the upper river, and instead of conducting it through an open canal it will carry it through the Victoria Park in pipes of large size. These pipes will be covered in order that they may not injure the scenic beauty of the magnificent park. The power station will be located at the water's edge in the gorge, a short distance below the famous point known as Table Rock. There the site is now being excavated with all possible speed, so that it may be clear for prompt building in the spring. The power station will be located not very far below the Horseshoe Fall, just about opposite Terrapin Point on Goat Island.

In the vicinity of the Dufferin Islands, on the Canadian side, above the Horseshoe Fall, the Ontario Power Co. has built a mammoth wing dam extending out into and down the river for about 800 ft. This dam has diverted all the water of the river from its customary channels about the islands, leaving the river bed dry over a large area. Never has there been such an opportunity afforded for studying the rock formation of the river bed above the great cataract. Thousands of people have visited the locality, and men of science from distant points are constantly inspecting the formation. After the Ontario Power Co. has constructed its works the river will be restored to the channels from which it has never before been diverted. The wing dam was built by Barry & Co.

While the Canadian side is the scene of this industrial activity, the town is having built a new

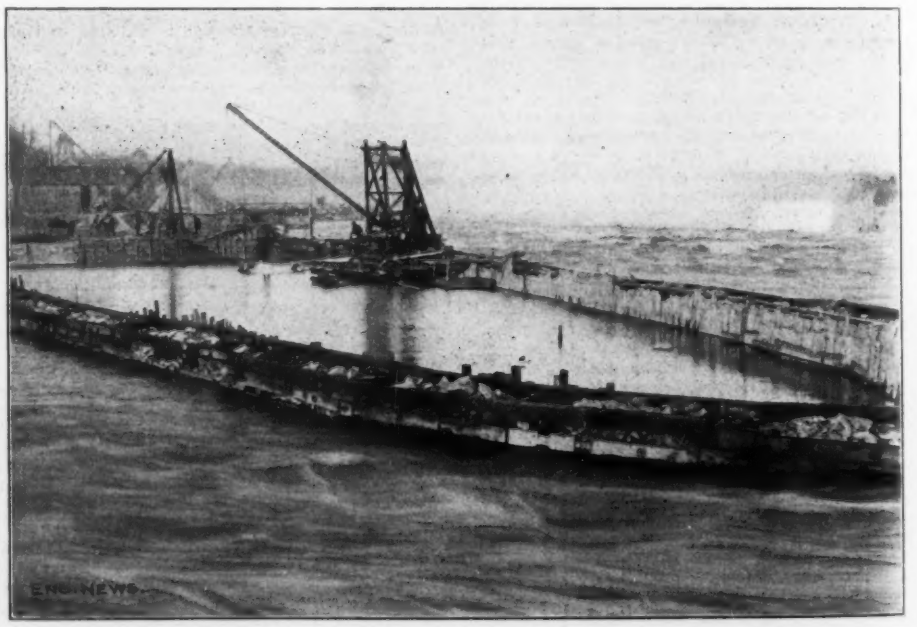

FIG. 4. COFFERDAM AROUND NEW WATER-WORKS INTAKE NEAR THE BRINK OF THE HORSESHOE FALL.

*Niagara Falls, N. Y.

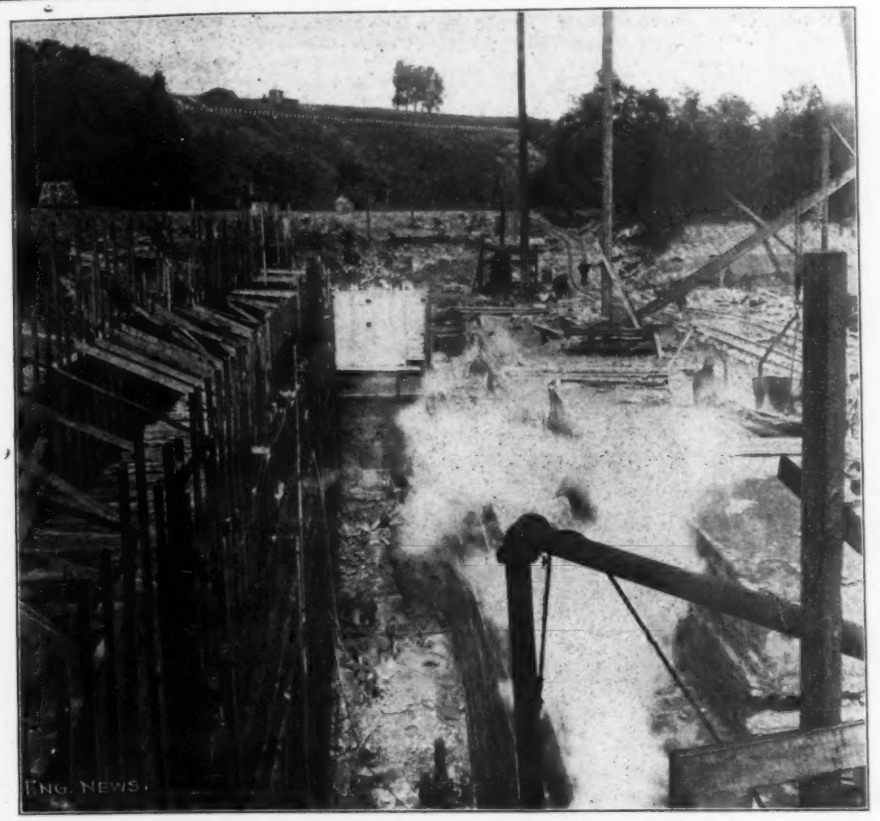

FIG. 3. EXCAVATING THE WHEEL-PIT FOR THE CANADIAN NIAGARA POWER CO.

water-works intake, which will also supply the station of the Niagara Falls Park & River Ry. This work is being done by Frazer & Emery.

All of the work of both the Canadian Niagara Power Co. and of the Ontario Power Co. is being prosecuted subject to the approval of James Wilson, superintendent of the Victoria Free Park.

SUGGESTED IMPROVEMENT OF THE SEWER SYSTEM OF CHICAGO.

At a meeting of the Chicago Academy of Sciences, in November, an address was given by Mr. George W. Jackson, M. W. S. C. E., on the subject of various municipal improvements. He first dealt with the new automatic telephone exchange system and the network of tunnels for telephone conduits, which have recently been described in our columns. He next took up the question of lowering the cable railway tunnels under the Chicago river to give the required depth for navigation and the required flowage capacity to the drainage canal. As a matter of fact, however, he considered that the new types of bascule bridges now being built so numerously across the river would give better service than the tunnels, and he estimated that six such bridges could be built for the sum required to lower one tunnel (including the reconstruction and extension of approaches). He estimated this latter cost at $1,500,0000, the work to occupy three years; while the six bridges could be built in 18 months for about the same amount. The principal part of the address, however, was devoted to the sewer system of the city, and we give below some extracts as to the present conditions and the proposed improvements:

The city has at present a system of sewers and catchbasins which on account of their unsanitary condition and the enormous expense of maintaining them should be done away with whether a subway or underground railway is or is not constructed. The present sewer system comprises brick catchbasins, brick sewers and tile pipe, not a connection being sealed in any manner. The catchbasins are about 10 ft. deep and 4 ft. inside, with 8-in. brick walls, and are built so that they will hold from 5 to 6 ft. of refuse. They are connected to the main sewer by a 9-in. tile pipe. The manholes are 3 ft. diameter inside, with 8-in. brick walls, and are located about 140 ft. apart. The main sewers are constructed of tile and brick and average 2½ ft. in diameter. The house connections are mostly made of 6-in. or 9-in. tile pipe. Each of the basins occupies a space of 5 ft. 4 ins. on each side of the street; the manholes occupy a space of 4 ft. 4 ins. in the center of the street, and the house connections are generally put in 25 ft. apart.

The present sewer system occupies about 15 ft. of the roadbed or over one-third of the entire space between curbs. The refuse and manure from our streets is swept into these catchbasins nightly. This refuse is left in the catchbasins before they are cleaned until the odor from the decayed matter becomes obnoxious or until an accumulation of decayed matter fills the catchbasins above the outlet. The cleaning of these catchbasins represents considerable expense, to say nothing of the repairs which are continually necessary in order to keep them connected to the main sewer, as well as to keep the covers in repair and keep the paving around the covers to grade.

Another unsanitary condition which exists in the streets, and which will be a great detriment in case a subway is built, is due to the different corporation manholes, which are connected to the main sewers with a 4-in. straight pipe. The corporation manholes have ventilated covers, and the gases arising from the sewer escape through these manholes and covers into the atmosphere. It is also a fact that the main sewer itself stands about half full of decayed matter at all times, generating gases which escape through the connections of the catchbasins and manholes. There are about 20 miles of this sewer system in the down town district. For cleaning the catchbasins and flushing the sewers, the city has an equipment of horses and what is known as the "slushing wagon." This slushing wagon is supposed to flush the sewers, which it cannot do for more than possibly half a block, when the smaller size sewers become stopped up on account of the sediment and sewage lodging and finally closing up the main sewer altogether. The cleaning of the catchbasins, the attempt to flush the sewers and the sweeping and cleaning of the streets represent a cost to the city of $350,000 yearly. A large part of this money can be saved, to say nothing of the large saving to the occupants of the buildings where the basements are used for merchandise, shops, etc., where losses occur to tenants and owners of buildings yearly from the back water, which occurs after heavy storms.

The remedy for this I believe is in building a new system of sewers on each side of the street, one system to be known as the storm water system, the other system to be known as the subsoil system. These two systems combined with a high-pressure water supply system would accomplish many sanitary and economical purposes. My idea is to build the subsoil system just outside of the curb wall, where house connections can be made without changing the sewer system now constructed inside the buildings. This subsoil system should be laid below datum, giving it the proper grade. The grade of our main sewers is less than ½-in. per 100 ft. Above this subsoil system a high-pressure water system should be constructed, also just outside of the area wall; connections should be made at each intersection from this water system to the subsoil system. This connection need not be over 3 inches in diameter. Employees of the city could make the rounds of these connections, and allow the water to discharge into the subsoil system, and so flush it out.

Above this water pressure system a storm water sewer system should be built. This storm water system can be given a large grade, for instance a storm water sewer starting say at Madison St. and the river, and extending east on Madison St. to Michigan Ave., would have a fall of about 8 ft. The grade of our street surface stands about 11 ft. above datum, or, in other words, about 11 ft. above the river. In connection with this storm water system, inlets should be built every 50 ft., or closer if necessary. The inlet would be a "T" pipe coming up to the top of the pavement, with a cover not over 6 ins. diameter. From the high-pressure water system connections should be run to the street surface to serve for washing the streets, as well as for fire purposes. The expense of building would not be very large, the two sewer systems need not be over 12 ins. diameter, and should be constructed of steel or cast-iron pipe, there being no engineering difficulties to overcome and no damages to take care of.

I have given some thought to the practicability of washing the streets in place of sweeping them. There is no question as to the economy of the two systems, and the

FIG. 2. VIEW OF PORTION OF RIVER BED UNDER CANADIAN RAPIDS LAID BARE BY WING DAM.

only reason that it has been impossible to clean our streets by flushing them is owing to the fact that the catchbasins, as I have mentioned, are about 140 ft. apart, which means the washing of all the sediment which accumulates on the streets to be washed a distance of at least 75 ft. With a storm water system as described, placing the inlets 50 ft. apart, the greatest distance from the inlet would be 25 ft. The present Commissioner of Public Works, seeing the economy in washing the streets, made a trial but was forced to give it up on account of the conditions above described. As to the high-pressure water system, it will not be at all necessary for me to speak of its merits, as the mayor has appointed a committee on the subject, and the fire marshal has installed part of a high-pressure system at the Stock Yards.

It might be objected that the sewers and mains would be in the way of the outlet from a subway. With these systems constructed, if it is finally decided to build a subway, it would mean possibly the changing of the system to run around the stations, requiring a possible change of not over 100 ft., which should be done without at all interfering with the service of the system.

TANK CARS WITH RIVETED TRUSS FRAMES.

One of the most interesting and novel forms of steel car construction is that adopted for some recently built tank cars, in which the side sills consist of riveted trusses, like pony bridge trusses. The first of these cars were built for the Illinois Sugar Refining Co., with tanks of 6,000 gallons capacity, for carrying glucose; the tank capacity has been increased to 7,000 gallons, and about a dozen cars of 6,000 and 7,000 gallons capacity are now in service for carrying oil. Fig. 1 gives general elevations of one of the cars. They were designed and built by the American Steel Foundry Co., of St. Louis, Mo., to which company we are indebted for plans and other information.

The cars have two center sills of 10-in. 20-lb. channels, placed back to back, 14 ins. apart. The two side sills are the riveted trusses, 7 ft. 2½ ins. apart. The ends of the side and center sills are riveted to cast steel end sills. The body bolsters, Fig. 2, are of cast steel, with a single web and broad top and bottom flanges; the bottom flange is shaped to form the center plate and side bearings, while the top flange extends to form a support for the running boards. The length is 9 ft. 6 ins. and the depth is 9 ins. at the center. At the two middle panel points of the trusses are plate connections extending below the bottom chord or sill and forming the attachment for transoms or needle beams, each composed of a pair of 10-in. 20-lb. steel channels. These are to carry the tank, which rests on a timber cradle and is held by four iron straps with threaded ends passing through the timber cradle. The tank is 6 ft. 10 ins. diameter inside and 24 ft. 11½ ins. long over all. It is made of ¼-in. steel plate, with lap joint, and has dished heads. On top is a dome 18 ins. diameter and 12 ins. high, having a bolted cover, with a valve in the top. At the center of the bottom of the tank is a 5-in. discharge valve. Within the tank is a coil of steam pipe, having a continuous fall towards the exhaust end, and projecting through the ends of the tank, where it is fitted with 1½-in. globe valves. The car is mounted on trucks having arch-bar or diamond frames (in which the upper arch bar is nearly horizontal and the lower tie bar is depressed), coiled springs and cast steel bolsters.

The truss construction is shown in Fig. 3, the length being 26 ft. 9 ins. and the depth 4 ft. In the end panels, 5 ft. 2 ins., the bottom boom is a 10-in. 20-lb. steel channel. In the intermediate and middle panels (5 ft. 7 3-16 ins. and 5 ft. 2⅝ ins.) the bottom chord is a single angle ⅜ × 3 × 4 ins., 16 ft. 8 ins. long. The end posts, top chord, posts and diagonals of each truss are all composed of single angles riveted to ⅜-in. gusset or connection plates. In the intermediate panels, however, the diagonals are composed each of a pair of angles. The rivets are ⅝-in. diameter, driven in 11-16-in. holes.

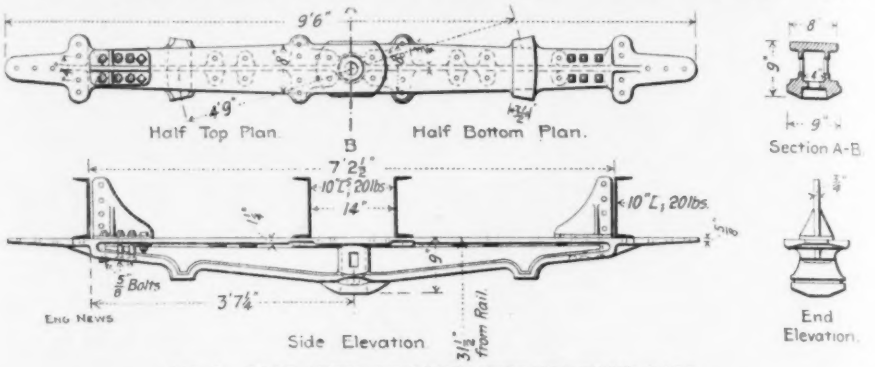

FIG. 2. CAST-STEEL BODY BOLSTER FOR TANK CARS.

In designing this type of car the tank was considered as being a uniformly distributed load, the full length of the center channel sills. These sills are supported by the body bolsters, and also by the channel needle beams or transoms, which latter are suspended from the side trusses. These trusses in turn are supported by the body bolsters and carry the greater part of the load. The principal dimensions of these cars are as follows:

Dimensions of Steel Tank Cars with Riveted Trusses.

Length over buffer castings on end sills	27 ft. 9 ins.
Length of side and center sills	26 " 9 "
Width between trusses	7 " 2½ "
Width over bolsters (extreme)	9 " 6 "
Depth of truss	4 " 0 "
Height, rail to top of truck bolster	1 " 10½ "
Rail to top of body bolster	2 " 7½ "
Rail to top of dome valve	12 " 7 "
Rail to center line of tank	7 " 3¾ "
Tank, diameter inside	6 " 10 "
Length over all	24 " 11½ "
Plates, thickness	¼-in.
Wheelbase, truck	5 ft. 2 ins.
Total	21 " 11 "
Distance, c. to c. of trucks	16 " 9 "
Wheels	2 " 9 "
Journals	5 × 9 "
Tank capacity	7,000 galls
Load capacity	80,000 lbs.
Weight empty	32,500 "

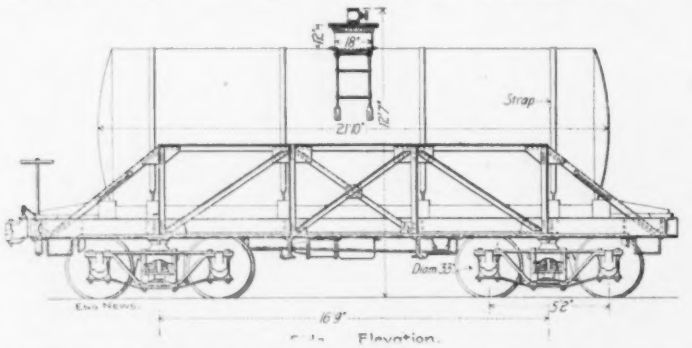

FIG. 1. TANK CAR WITH TRUSS FRAMES. American Steel Foundry Co., St. Louis, Mo., Builders.

THE METRIC SYSTEM.*

By F. A. Halsey,† M. Am. Soc. M. E.

The situation at Washington regarding our system of weights and measures demands the most serious consideration. The testimony before the House Committee on Coinage, Weights and Measures was overwhelmingly one-sided, and, weighing such testimony in the only way that Congressmen can, the committee could bring in no other report than the one it did, recommending the passage of the Metric System bill. Scientific and practical men of the front rank, as well as engineering, scientific, and trade societies everywhere, are calling for this measure. The Western Society of Engineers, by a mail ballot, voted for it by over 5 to 1. The Franklin Institute, with Samuel Vauclain, James Christie, and Wilfred Lewis on its committee, has also endorsed it. With the report of the Franklin Institute were transmitted to the House committee 21 letters from "various large manufacturing firms, particularly manufacturers of machinery," which had been received in answer to a circular letter of inquiry, of which 20 favored the metric system.

The pro-metric argument is substantially, an old one, and argument. The metric advocates adopt the methods of the old philosophers who laboriously sought to prove what ought to be. My method is that of modern science, which interrogates nature in order to learn what is. For instance, they tell us how easily and how quickly this nation ought to make this change; I shall show how slowly and laboriously France and Germany have made the change. They will say that we ought to adopt this system to please our foreign customers; I shall show that our foreign customers do not care one picayune whether we adopt it or not, and I shall prove it by a flood of evidence.

THE PERSISTENCE OF OLD UNITS IN GERMAN TEXTILE INDUSTRIES.

The testimony before the House committee is sprinkled with opinions that this great change can be made in from three to five years.

At the presentation of this paper there will be offered for inspection a collection of French and German books from the library of the "Textile World." These books present a condition of things which is absolutely startling. As instructive as any is a little German book of 105 pages, "Calculator for Articles in the Textile Industries," by Friedrich Frowen, third edition, 1901. The object of this book is to give a simplified system of calculating for textile fabrics, and it discloses a condition of things in German-speaking Europe compared with which our own is simple indeed. This condition is due to the fact that there are still in use nine different ells in addition to the meter and the English yard. These ells are divided into inches, an inch ranging all the way between 1-20 and 1-36 of an ell, and such extraordinary ratios as these being still in use:

Prussian ell	25½ ins.
Würtemberg ell	34¼ "
Vienna ell	29½ "

In brief the book shows that there is still in use in German textile mills an absolute medley of ells, inches, yards, meters, kilograms, and pounds, combined with a vast number of systems of yarn numbering based upon these different units of length and weight, while towering above all these systems of yarn numbering are found the English yard and pound in all branches except the silk industry, in which the metric system cuts a very small figure.

In the "Textile World" for October, 1902, is an article by Mr. Dale, into which he has lifted bodily one of Frowen's simplified calculations of the cost of a piece of worsted cloth, and to it he adds this description of the operations performed:

The raw material is purchased by the English pound. The finished goods are sold by the French meter. The yarn counts are English, while the length and width of the finished goods are metric. The length of the yarn is expressed in meters, while the counts are English, based upon the yard and the pound. From this hodgepodge the weight of the yarn is calculated in grams, which is extended by another arithmetical somersault at a price given in marks per English pound, and to cap the climax the total length of the yarn in meters is reduced to English yards and then to English skeins of 560 yards each.

There is no theory here. This estimate is an example of German practice at this moment, and yet men can be found who say that the metric system was adopted in Germany in two years without inconvenience, some asserting they were present when the trick was done; and stranger still, other men can be found who believe it.

Note that this example is relatively a simple one, because it contains none of the ells nor inches, but relates to yards, meters, pounds, and grams only. It hence represents exactly the condition which the adoption of the metric system would bring about in our own mills.

THE PERSISTENCE OF OLD UNITS IN FRENCH TEXTILE INDUSTRIES.

In France the condition is, if possible, still worse. Illustrating this may be cited "Traite Theoretique et Pra-

*Extracts from a paper presented at the New York meeting of the American Society of Mechanical Engineers.

†Associate Editor "American Machinist," World Building, New York City.

tique de Tissage" (Theoretical and Practical Treatise on Weaving), by Paul Lamoitier, 1900. This is a standard French work on textiles of 573 pages. On page 27 may be seen a comparative yarn table giving equivalents of the following systems of yarn counting, which are thus compared because they are still in use:

Worsted—Metric, Roubaix, Reims, Fourmies, English, German.

On page 63 is an illuminating sentence. Opening a section on yarn numbering for linen, hemp, and jute is this sentence: "On emploie le titrage anglais" (We use the English system of numbering yarn). Following this comes the following beautiful example of how the decimal system has swept all before it in France:

The lea is 300 yards, or 274.2 meters; 12 leas make a skein of 3,600 yds.; 100 skeins a bundle of 360,000 yds.

Perhaps the most curious example of all in the French textile industries is the count of the weft threads in the fabric—the number of "picks" of the loom. Here, if anywhere, it would seem to be easy to introduce the centimeter, but nevertheless the French weaver counts his picks by the inch (pouce), and (save the mark!) 37 French inches equal 1 meter.

In these books are pages after pages of conversion tables between the various ells and between the ells and the yard and meter, added to which are conversion formulas making a total which is fairly maddening. These comparative calculations and reductions are an essential part of all French and German textile literature. A French or German work on textiles dealing with metric weights and measures alone would be worthless to 99% of the French and German textile industry.

The meaning of all this, and the lesson to be learned from it, is not, however, that the textile industries of France and Germany are infinitely worse off than our own as regards their systems of weights and measures, nor that their textile calculations are infinitely more laborious than ours (both of which, however, are facts), but that 28 years after the compulsory adoption of the metric system in Germany the old units still persist to an extent calling for such books, and that, in France, a 100 years of time, national pride, and a despotic government combined have not succeeded in killing the old units. The only effect of the adoption of the metric system in both of these countries has been to add a new set of units to the old ones. Shall history repeat itself here?

PERSISTENCE OF OLD UNITS IN GERMAN MECHANICAL INDUSTRIES.

In the "American Machinist" for May 3, 1900, is an article by Mr. Henry Hess, of Berlin, Germany, on metric screw threads. Mr. Hess was formerly with the Niles Tool Works, of Hamilton, Ohio, and when the corporation established its great branch works in Berlin, under the name of the German Niles Works, he was selected to go to Germany, in order to carry American practice and American methods there. Mr. Hess writes:

To work with both millimeters and inches in the same shop, and not infrequently on different portions of a single piece, is too illogical an arrangement to maintain itself. A further complication is brought about by the fact that, though like in name, an inch is a widely varying quantity in different sections. In Germany alone there are at least half a dozen, of which two, the Rhenish and the English, are in such very general use as to cause great confusion.

It is quite true that the great majority of these [old provincial inches] are no longer in use; still it is to-day necessary to be very careful in using rules that are purchasable in every hardware store, to make sure whether the inches that are given on the reversed side are Rhenish or English inches.

Nearly universally the carpenters and other building mechanics use the Rhenish inch, and we have occasionally found that men in our shops have made use of their private Rhenish foot-rules.

In talking with the proprietor of a large retail hardware shop in Berlin, I learned that practically all of the small tradesmen with whom he has to deal still stick to the use of the inch, and when they want to sell them anything according to meters, they are informed that they are used to the inch and foot and do not wish to be bothered with the meter.

To understand the full force of this it must be remembered that to sell goods by other than metric measures in Germany is a finable offence, and Mr. Hess's informant has, in fact, paid such fines for acceding to his customers' demands.

Do not forget that this condition of things obtains 28 years after the metric system was made compulsory in Germany. Our manufacturing interests and methods are immensely more developed than those of Germany 28 years ago, with a corresponding increase of difficulty in changing, and yet, with the change incomplete, in Germany after 28 years, these people go to Washington and give it as their opinion that with us, and without compulsion, three to five years will do it all.

PERSISTENCE OF OLD UNITS IN SPANISH-AMERICA.

The most recent star example of quick change in weights and measures to which the metric advocates point is Mexico. Mr. Troemner testified:

Only recently, within the past two weeks, I talked with the Commissioner of Mines of Mexico, who visited me, and he told me the metric system was working magnificently in Mexico and that they had made the jump at once from one standard to the other.

Following is an extract from a letter from the Superintendent of Machinery of the Mexican Central Railway, Mr. Ben Johnson, dated at Mexico City, Oct. 7, 1902:

We use nothing whatever but American measurements in the work of the mechanical department. Our drawings of locomotives and cars and our shop tools are all in American measurements, and as far as my information goes, this is the case with nearly all railroads in Mexico.

The Mexican Commissioner of Mines has, it is clear, no knowledge of the practice of Mexican railroads. What reason is there for supposing that he has any knowledge of other interests outside his immediate personal experience?

The metric system of weights and measures became compulsory in Mexico, Jan. 1, 1884.

At the Indianapolis meeting of the National Association of Manufacturers I had a long conversation with Mr. Rudolf Dolge, who, as a representative of that association, has traveled extensively in Europe, China, and Venezuela, in which last country he has lived for four years, having had charge of the warehouse of the association at Caracas, Venezuela. He says that in Venezuela the meter is practically unknown, the old vara being the commercial unit of length. For the claim that the meter is, in any real sense, established as an international unit he has nothing but contempt.

The fatal mistake of the metric advocates and the weakness of their case lies in their assumption that the statute book is an index of the practice of the people.

The argument for the saving of time in calculation, for the simplification of our weights and measures and for the saving of time by school children are all based on the tacit assumption that the old units are to disappear. As they have not done so elsewhere they will not do so here, and every one of these arguments falls to the ground.

Shall we carry our heads in the clouds of speculation, or shall we consult the experience of others? Shall we join in the chase of this will-o'-the-wisp which no nation has ever caught? That and that only is the metric question of the hour. Arguments based on the "beautiful interrelation and correlation of the units" have little more application than a philosophical speculation regarding the appearance of the back side of the moon.

REASONS FOR THE LENGTH OF THE TRANSITION PERIOD.

The pamphlet containing the testimony before the House committee contains a letter from the Brown & Sharpe Manufacturing Co.—in which is a sentence embodying more wisdom and knowledge of the subject than all the pro-metric testimony. I quote: "The question of weights deals rather with the future, but . . . MEASURES OF LENGTH ARE TIED IRREVOCABLY TO THE PAST." The man who wrote that sentence was inspired, and for a time it will become my text.

If the metric system were made compulsory to-morrow, and the people were to receive it with enthusiasm, the gas pipes in the ceilings of our homes along would keep the old system alive for 50 years. Remember the proof that has been given that the metric system necessitates metric sizes. Now make the gas tips which we replace so often with metric threads, and there isn't a chandelier in this country that will take them. Make the chandeliers with metric threads, and there isn't a gas pipe end projecting from a single ceiling in this country which will take them. A fair question to ask here is, how long does it take on the average for a gas pipe to wear out? Our friends tell us that for a time we will use transition fittings with English threads at one end and metric threads at the other, but this begs the whole question. The transition fittings must be made. The length of the pipe does not alter the thread or the tools for making it. The tools and the equipment must be preserved. But why make a transition fitting at extra cost and serving no purpose except to furnish an added joint to leak? We may be sure that so long as pipes with English threads endure in our ceilings, chandeliers will be made with English threads to fit them. Why is this? Because "measures of length are tied irrevocably to the past."

Every factory contains overhead lines of shafting which with the pulleys to fit are a standardized line of manufacture. With standard fits pulleys may be changed from place to place by simply removing and replacing. Put up a metric line shaft, and not a pulley in this country will fit it, nor will any metric pulley fit an English line shaft. A line of shafting was scarcely ever known to wear out. I know one which is 40 years old, and it was, I believe, second-hand when I made its acquaintance. So long as existing shafts endure we may be sure English dimension pulleys will be made to fit them. Why? Again, because "measures of length are tied irrevocably to the past."

They tell us that we may continue to use the old units in repairs. Consider the couplings which connect the air-brake hose on all railroad cars. A new coupling on one car connects with the old one on another car. The time will never come when that can be changed, unless they are all changed at once. Why? Because "measures of length are tied irrevocably to the past."

The early French settlers of St. Louis and vicinity laid out their land in arpents. . . . Since that time the territory has passed from French into Spanish hands, and from Spanish into our own. But to-day there is scarcely a piece of real estate in St. Louis that is not measured in arpents. Why? Because "measures of length are tied irrevocably to the past."

THE ADOPTION OF THE METRIC SYSTEM NECESSITATES ABANDONING MECHANICAL STANDARDS.

The metric advocates tell us that it is not necessary, nor is it desired to destroy our existing standards, and the report of the House committee contains these naive words:

This measure in no way contemplates any change in existing technical standards, such as screw threads, wire gages, lumber measures, and numerous others, except as manufacturers and other interests find it to their common interest to make the change.

Unless, however, this metric programme contemplates the ultimate disappearance of the inch and the substitution therefor of the millimeter, it is meaningless and purposeless, and I venture to say that if even the House committee really supposed that the only intention of this measure is to add another set of units without getting rid of the old ones, they would have unhesitatingly killed the bill. That, however, has been the effect in France and Germany, and, according to the House committee's report, that only is its purpose here. Proposing to change some things and not others begs the whole question. The proposal to make the easy changes but not the difficult ones, is a tacit acknowledgment that some of the changes are too difficult to make, which is exactly the anti-metric position. To suggest that we make the easy changes but not the difficult ones is to surrender the whole case.

Another suggestion constantly made is that we continue to use our present sizes, especially of standards, but give metric equivalents for the present English dimensions.

To prove this to be impossible it is only necessary to construct a table of metric equivalents of the usual fractional dimensions, thus:

Ins.	Metric equivalent.	Ins.	Metric equivalent.
1	25.4	2	50.8
1⅛	28.57	2⅛	53.97
1¼	31.75	2¼	57.15
1⅜	34.92	2⅜	60.32
1½	38.10	2½	63.5
1⅝	41.27	2⅝	66.67
1¾	44.45	2¾	69.85
1⅞	47.62	2⅞	73.02

Is not the point obvious at a glance? While the law of the series is simple enough, it is not obvious to the eye, and the man does not live who can memorize the list.

Imagine this table to be a bolt list. A farmer has broken a 28.6 millimeter bolt and wants a larger one, but neither he nor any one can tell what size to call for without calculation or consulting a list. Are we all to carry a list of bolt sizes in our pockets? Will some one point the gain due to calling a 1⅛-in. bolt a 28.6-millimeter bolt, or give any reason which should lead any one to use the metric figures?

In a certain stock-room the interval between the sizes of bar iron carried is ¼-in. Two of the sizes in stock are 2½ and 2¾ ins. The metric equivalent of the former is 63.4 millimeters. Will some metric enthusiast, without calculation, kindly name the next metric size? Will he name any metric size upon the list except those corresponding to even inches? Will he say if he ever expects to be able to name one-quarter of the sizes used in every tool and stock room? If he thinks he can memorize the table as given, does he think he could do it after the sixteenths are added? If he does, how will the matter stand after the table is extended to, say, 10 ins.? If he finally

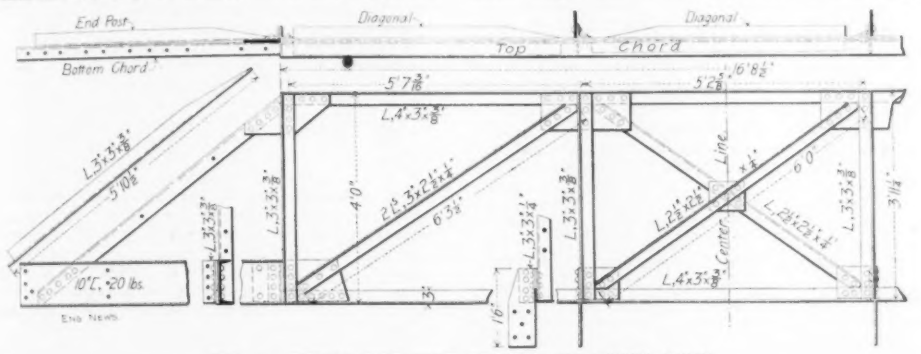

FIG. 3. TRUSS FOR SIDE FRAMES OF TANK CARS.

gives up the task of memorizing the table, will he say if he intends to carry a list of equivalents in his pocket, or, failing that, whether he expects to use a lead-pencil or a slide rule whenever he has occasion to call for a tool or a bar of iron? He must do one or the other, or else use the English figures. Do the metric enthusiasts really think that during the "transition period" any one will calculate metric dimensions which cannot be memorized when he can use English dimensions which memorize themselves.

Why do the Germans use their inches instead of metric equivalents? They do not use the equivalents because they cannot, and they cannot for the reason here given.

All plans for saving existing standards depend upon the continued use of the inch or upon the use of metric equivalents. The latter plan being impossible, it follows that the abandonment of the inch involves the abandonment of all existing mechanical standards. This idea of metric equivalents has led more men astray than almost any other. It is absolutely chimerical.

And what is it all for? The metric advocates can answer best.

In answer to the question, What would be the advantage to the general public—the plain people—throughout the country by the adoption of this system? Professor Newcomb answered:

> The advantage would simply be that of simplicity. . . . So far as every-day purposes are concerned I do not know of any particular advantage. . . .

Dr. Geddings says (read this to slow music):

> It is simple, elastic, scientific, and on the whole a beautiful structure, and the interrelation and the beautiful correlation which exist between its measures of weight and measures of capacity, and its measures of length and area, I think only require a very limited consideration to appeal to any one who is desirous of getting into the ranks of the progress of the age.

And so on to the end of the wearisome chapter. Was there ever such a case of sacrificing the greater to the lesser? Was there ever such a case of distorted perspective? Was there ever such a case of rainbow chasing? Are we a nation of dreaming idealists and transcendentalists that we should be swayed by such considerations?

The points I have now made are that this supposed universality of the metric system, even in countries in which it has been nominally adopted for a generation, is a fiction; that the idea, which is repeatedly insisted on by these people, that we can make this change in three to five years is rubbish; and that the adoption of the metric system, whatever its advocates may say, does involve the destruction of our existing standards.

EXAMINATION OF THE CLAIMS OF SUPERIORITY FOR THE METRIC SYSTEM.

Admit all, for the sake of argument, that the metric advocates have claimed regarding the fundamental superiority of the system and we admit nothing. The prometric argument is that the decimal basis and the interrelation of the units of length, of capacity, and of weight greatly simplify and abbreviate calculations. That is all, for when it comes to actually measuring things no one claims that it cannot be done just as readily by the English system; and, in fact, if there is any argument from this standpoint it is that the English system is better than the French system.

Which system involves the more figures in calculation no one can say a priori with any certainty. Please note my words. Two factors enter the matter, one of which favors the English, and the other the metric system. The factor which favors the English system is the smallness of the French unit—the millimeter, which is about equal to the one-twenty-fifth part of an inch.

In the practical use of the metric system in machine construction, the millimeter and not the meter, as originally intended, is the unit of length—that is, the figure 1 means 1 millimeter, and not 1 meter. To express 1 meter we write 1,000. The meter, as such, does not appear upon the drawing at all. Eight meters appear as 8,000 millimeters—and what a charming expression that is—it reminds me of nothing so much as measuring the distance to the moon in inches. And this must be so, because we cannot have two decimal points. In the nature of the case, for any class of work, we must first fix the position of the decimal point and then keep it there. Fancy a ledger in which the decimal point sometimes appeared after the dollars and sometimes after the cents. By common consent in metric countries and for machine construction the point is placed after the millimeters.

Even the assumed simplicity of decimal fractions is to a large degree fictitious. Compare the following table of equivalents:

$\frac{1}{3} = .3333+$	$\frac{1}{60} = .0166+$	$\frac{1}{16} = .0625$
$\frac{1}{4} = .25$	$\frac{1}{70} = .0143+$	$\frac{1}{32} = .03125$
$\frac{1}{5} = .2$	$\frac{1}{80} = .0125$	$\frac{1}{64} = .015625$
$\frac{1}{6} = .1666+$	$\frac{1}{90} = .0111+$	$\frac{1}{350} = .0028+$
$\frac{1}{7} = .1428+$	$\frac{1}{200} = .005$	$\frac{1}{450} = .0022+$
$\frac{1}{8} = .125$	$\frac{1}{300} = .0033+$	$\frac{1}{550} = .0018+$
$\frac{1}{9} = .1111+$		

Read some of these expressions aloud. One-eighth equals one hundred twenty-five thousandths; one sixtieth equals one hundred sixty-seven ten thousandths; one thirty-second equals three thousand one hundred twenty-five hundred thousandths. Can any one say that the decimal equivalents give as clear a mental picture of their value as the vulgar fractions? They never do, except where the decimal is small, and this explains why people insist on using vulgar fractions.

The superiority of the decimal system as applied to currency is largely due to the great amount of adding to be done. With day book, journal, ledger, cash book, trial balance, balance sheet, invoice inward and invoice outward alike, it is add, add, add, and then add some more. The amount of adding to be done in connection with money is both relatively and absolutely out of all comparison with that involved in connection with weights and measures. When it comes to multiplication or division, vulgar fractions are often the simpler. The comparisons drawn between currency and weights and measures will not bear examination.

Suppose, for the sake of argument, that the labors of naval architects and engineers generally were appreciably lightened by the use of the metric system, what would it amount to? What is the proportion of engineers to the public at large, and how much would the aggregate saving amount to? Figure up the aggregate if it can be done, and then divide it by the number of the population, and how many seconds per day for each man would be obtained? This explains what I meant in saying that if the arguments of the metric advocates be admitted the admission amounts to nothing. As an economic factor in the life of this people, I insist that the saving of time due to the use of the metric system in calculation is an absolute bagatelle. The only field in which the interrelation of the units cuts any considerable figure is the electrical field. This narrows the issue still more. Shall we do this for the electrical engineers?

Moreover, the entire argument for this saving of time in calculation is based on the tacit assumption that the old units will become extinct since, if they are to be used, they must appear in calculations. When, as in French and German textile industries, the old and new units are used conjointly, there is an actual loss of many times the theoretical gain.

Witness the closing of the grave over a century of delusion regarding a wonderful saving of time in calculations, to be obtained by the adoption of the metric system.

THE VALUE OF MECHANICAL STANDARDS.

If what has preceded has proven anything whatever, it is that the idea of using metric equivalents for English dimensions must be given up. If this idea must be given up, the inevitable conclusion is that the abandonment of the inch will involve the destruction of our existing standards.

The destruction of our existing standards! A few words, not even a complete sentence. They are easily spoken, but does any one who reads this paper appreciate their appalling meaning, the industrial chaos to which their destruction would consign us? Established industrial standards are among the most priceless of material possessions, and the man who would destroy them deserves to be placed in the pillory and held up to the scorn of men.

The man who can estimate or indicate in words the value of mechanical standards to this country and the loss due to their destruction does not live, and I shall not attempt it. The pamphlet containing the testimony before the House committee is full of questions and of testimony from the metric advocates, the purpose of which is to show that the cost of changing standardized tools is, after all, not very serious, if done gradually, but nowhere is there anything to indicate that these people have any idea of the value of a standard as such. For their benefit, therefore, I will explain that while the value of standardized tools in this country runs into unnumbered millions of dollars, the value of a standard is not chiefly or even largely represented by such tools.

The chief value of a standard lies in the fact that it is adopted, that it has become a part of our daily lives, and works so smoothly that we are scarcely aware of its existence. For example, the value of pipe-thread standards is not represented by the taps and dies in the hands of pipe makers and fitters, but by the fact that because the threads are standardized pipe fittings can be made by the million, at trifling cost, and that when we need a fitting we can buy it for a few cents with the assurance that it will fit, instead of having to get it cut to order to suit an odd size of thread. Similarly the cost of attempting to change air-brake hose couplings is not represented by the value of the tools for making the couplings in the Westinghouse Works, but by the infinite confusion of the railroads in getting from one standard to another. The value of the tools in this case is not many dollars, but the cost of the change cannot be found upon any inventory, nor can it be measured by any scale.

Similarly again, the cost of changing our pipe-thread standard is not represented by the cost of new taps and dies, but by the confusion involved in getting from one standard to another—a confusion which will last until existing steam, water, and gas pipes have disappeared, and which will not be lessened by putting off the change until it is brought about "at the suggestion and convenience of manufacturers."

It is because of our standards and our standardized methods that American mechanical industries are great. It is in this that we lead, and by this sign we conquer. It is this that distinguishes us from the remainder of the world, and having the lead which such things give us, we are asked to abandon it and line up in the race afresh. And this in the name of progress!

Next to language, weights and measures are the most fundamental of our possessions. All knowledge is comparative, and comparison is impossible, except through the use of weights and measures. Take away our measures of length, of weight, of capacity, of value, and of time, and no life beyond that of the most primitive savage is possible. With this fundamental nature goes a corresponding difficulty of change—a difficulty which there is abundant proof, is only equalled by the difficulty of changing language itself. Practically both are upon a par, for I believe it to be just as impossible for this people to change its weights and measures as to change its language. No nation in modern times has ever gotten rid of an old system, as my argument has shown for the cases of France and Germany.

As my argument relates chiefly to measures of length as used in machine construction, it is important to explain the different bases upon which measures of length and other measures stand. The simplicity, universality, and cheapness of commercial measures of capacity and of weight are obvious to all. The gallon measure and the counter and platform scales of the grocer cost but little, while they weigh and measure all his commodities, except those sold by count. Contrasted with this, commercial measures of length as used in the machine shop are numbered by the hundred and by the thousand, and are of a far higher degree of precision than measures of weight and of capacity. There is no reason why every gallon of molasses should be the same—to the last drop—as every other gallon, and there is no reason why the weight of a barrel of flour should agree, to the last fraction of a scruple, with every other barrel. Precision in these things is merely a commercial matter, and the commodities have not enough value to justify the cost of minute accuracy in measuring them.

In the case of measures of length in the machine shop a new element enters. We do not make a given piece of a machine to a precise size, because we fear the customer will get more iron or steel than he pays for, or for fear he will complain if we do not give him all he pays for. We make it to precise size in order that all similar pieces may be alike. The feature of interchangeability, which is a necessity of economical manufacture, compels these measures to be made with a degree of precision to which there is no parallel in commerce elsewhere. A thousandth of an inch of error represents a very common degree of accuracy, and no work which does not come within a quarter of a thousandth can be called precise. A tenth of a thousandth is sometimes seen, while standard gages are guaranteed to be correct within a fiftieth of a thousandth of an inch.

This phase of the subject has, however, a far wider application than to the machine shop. This is the mechanical age. Without machinery is nothing made that is made. The machine building industry is the foundation industry of modern life.

To cripple the machine shop is to cripple every other industry under the sun, and to defend the machine shop, directly, is to defend, indirectly, every industry by which the American people thrive, and prosper, and earn their daily bread. It is to defend even those industries whose representatives go to Washington and declare that they want this thing; for I want to say that when these men go there, and in their mistaken zeal seek to crucify the English system of weights and measures, they simply know not what they do.

There are many industries in which measurements play a subordinate part. We may buy a shipload of grain by specifying the number of bushels, or of pig-iron, or of coal, by naming the number of tons. But when we buy a machine we buy measurements by the hundred. The Cincinnati Milling Machine Co. inform me that one of their medium-sized milling machines, selling for $650, contains, including the pattern work, 18,300 dimensions—that is, a little over 28 dimensions for each dollar of value. Of these, the majority probably require to be correct to the thousandth of an inch, and many of them to a much higher degree of precision than that. I think this illustration will make it plain why this matter is of such momentous importance to the machine building industry, and why this society should be united in this matter.

OF THE INCOMPETENCE OF CERTAIN TESTIMONY.

Much of the testimony offered at Washington has no significance whatever. The mere "It's a good thing, push it along," of some commercial man, even of the most exalted station, should have no weight, for he can have no knowledge of constructive measurements. Nor should the testimony of scientific enthusiasts, who are captivated by the nicety of the thing. This is in no sense an academic question. The industrial use of measurements is in the making of things, and hence this is a factory question, and not a laboratory, or a study question at all. There is, however, one class of testimony which deserves fuller notice—that of many engineers and engineering societies who endorse this bill. It may well be asked why the views of these engineers are not entitled to as much respect as our own. These men are chiefly civil engineers, and their societies are chiefly civil engineering societies. Except for the Franklin Institute—whose mechanical sec-

tion is but one of many—no mechanical engineering society has, I believe, endorsed this measure. It may still be asked why civil engineers are not entitled to their views as well as we. They are, regarding their own units, but not regarding ours. Civil engineers deal with constructive measurements, but a characteristic of their work is that each piece of it, be it bridge, canal, or dam, is complete in itself, designed and built for its place and work, and in its measurements has little to connect it with the past or future. There are, however, two classes of measurements which are especially within the province of the civil engineer—land and angular measurements, of which the former are expressly exempted from the operation of this bill. Angular measurements are also within the special provisions of the American and Canadian astronomers, the superintendent of the coast survey, and the American astronomical instrument maker, who testified before the House committee in favor of the bill. These gentlemen are distinguished men. No one honors their achievements more highly than I, but that does not change the facts about their testimony.

Our angular measurements are as illogical as any. It is just as illogical to divide the quadrant into 90 degrees, and each degree into 60 minutes, as to divide the pound into 16 ounces, or the foot into 12 inches. An integral part of the metric system in its entirety is a new system of angular measurements, in which the quadrant is divided into 100 degrees, and each degree into 100 minutes.

We hear no call from civil engineers for a new set of units of land measure. Why? Because in land measure it is too plain to be overlooked that "measures of length are tied irrevocably to the past"; hence civil engineers will not have such measures changed. We hear no call from civil engineering or astronomical circles for a new system of angular units. Why? Because, were the change made, not an old observation or record could be read in the new units, nor a new observation in the old units. Measures of angles, like those of length, are "tied irrevocably to the past," and hence these men will not even consider a change in angular units. Their motives are not to be impugned; they see their own side of the shield, and do not see ours; but, nevertheless, until these gentlemen are prepared to accept a change in their own special units, they are estopped from urging a change in ours. What a spectacle for gods and men is a civil engineer, urging a new set of units which do not include those for land and angular measurements!

I can imagine no more appropriate close for this paper than another reference to Mr. Stratton's testimony. Said he:

> Let us take for example the most serious objection of all, which is that we have learned to think in the old system of weights and measures.

Does Mr. Stratton seriously consider that the persistence of the ells in Continental Europe, and of the vara in South America, can be explained at this late day by saying that the people "have learned to think in the old system"? Can he see nothing but this in the use of the carat for weighing jewels by people who, presumably, use the gram for everything else? Is it not plain to him by this time that the objection which to him appears to be the "most serious of all," is, in reality, dwarfed by the fact that "measures of length are tied irrevocably to the past"?

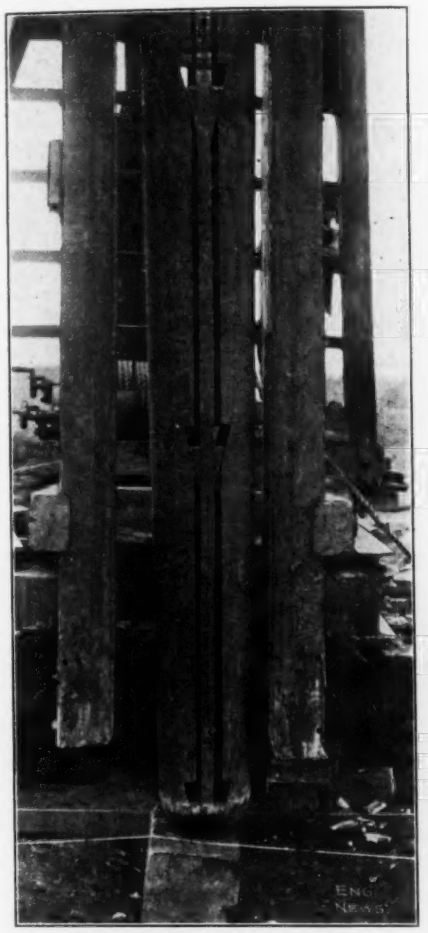

Fig. 1. Core Expanded for Driving.

Fig. 2. Core Collapsed for Withdrawing.

STEEL PILE OR CORE FOR MAKING HOLES FOR CONCRETE PILES.
Raymond Concrete Pile Co., Chicago.

CONCRETE PILE FOUNDATIONS AT AURORA, ILL.

The new Carnegie public library at Aurora, Ill., will have foundations of concrete piles reaching through 14 ft. of filled material to solid rock. The material includes large quantities of gravel and cinders, and contains large blocks of stone. The method of construction of these piles was described in our issue of June 20, 1901. It consists in first driving a steel pile fitted with a sheet-iron shell. The pile or core is collapsible, and when fully driven it is collapsed so as to be withdrawn, leaving the shell in place. The hole thus left is filled with concrete. The accompanying illustrations show the steel pile as set up and collapsed, its construction differing from that described in the article above mentioned. It consists of two longitudinal cast-steel pieces, A, A, between which is fitted a cast-steel key, B, with wedge-shaped lugs. When the pile is assembled for driving, these lugs spread the two side pieces apart, and the three parts are secured in position by a horizontal key, C, through the head of the pile. This position is shown in Fig. 1. When the pile is driven, the top key, C, is knocked out, a vertical pulling strain is set upon the key piece, B, and the two side pieces are driven down by a tap of the hammer, so that recesses in their edges slip over the lugs on the key piece, allowing the side pieces to move inward and come in close contact with the key piece, as shown in Fig. 2.

The Aurora public library will have 142 piles, 20 ins. diameter at the top and 13 ins. at the bottom, this slight taper being adopted on account of the holes being sunk to rock. The pile driver is mounted on a turntable and has a 2,400-lb. hammer, the drop being 20 to 25 ft., and the penetration ranging from 2 ins. to ⅛-in. An iron cap or follower fits on the beveled head of the pile. The shell which prevents the earth from caving in when the steel pile or core is withdrawn is of No. 20 sheet iron. The concrete is composed of 1 part Portland cement, 2 parts sand and 4 parts stone. The heads of the piles are afterwards enclosed in concrete foundation walls, 18 ins. deep, as shown in Fig. 3. The building will cost about $50,000, and the architects are W. A. Otis and B. E. Holden, 175 Dearborn St., Chicago. The foundations are being put in by the Raymond Concrete Pile Co., 135 Adams St., Chicago.

Fig. 3. Building Concrete Foundation Wall in which the Heads of Concrete Piles are Embedded.

SUPERHEATED STEAM.*

By E. H. Foster,† M. Am. Soc. M. E.

There have probably been as many as 7,000, and possibly more, superheaters successfully installed by European manufacturers during the past 10 or 15 years, and the fact that the number of installations is rapidly increasing is the best proof that they are on the right track.

The general method of superheating steam is to take the saturated steam from a boiler drum and pass it through coils surrounded by heated gases. The coils may be placed within the boiler setting so as to intercept the gases from the boiler furnace in their passage through the boiler, or they may be placed in a setting independent of the boiler and supplied with heat by a furnace of their own, or they may be set outside of the boiler and supplied with heat by drawing a portion of the hot gases from the boiler furnace, passing it through the superheater and returning it to the boiler or economizer. The choice of a system must depend largely upon local conditions, such as space available, the style and size of boiler in use, arrangement of the steam piping, type of engines adopted and their location with reference to the boilers.

The coils are made of seamless drawn steel tubing, or of cast iron of a suitable composition to stand high temperatures, important advantages being claimed for each. Whatever the method of construction adopted, the material used must be of the very best and the joints and connections made in the most approved manner and with the greatest care. With such precautions as are now considered good practice the superheater may be depended upon as safely as the boiler, or engine, or any other part of the plant.

*Condensed from a paper read at the New York Meeting of the Engine Builders' Association of the United States.
†126 Liberty St., New York city.

In considering the advantages and disadvantages of superheating with regard to engine work, let us recognize the four distinct conditions under which steam is used as follows:

(1) Saturated.
(2) Superdried.
(3) Moderately superheated.
(4) Highly superheated.

Saturated steam may be taken as commercially dry steam, or such as is delivered by a good boiler under ordinary conditions.

By superdried steam we mean steam which is not only thoroughly dried in the superheater, but which is raised in temperature 30 or 40° above the saturation point, or just enough to insure its arriving at the engine in a perfectly dry state. To such an arrangement there could possibly be no objection, as the steam is delivered at the engine free from moisture and without the use of a separator or means of trapping out condensation.

By a moderate superheat we mean from 100° to 150° at the boiler, which should give in the neighborhood of 100° at the engine and be sufficient, with proper protection, to carry the steam nearly, if not quite, through one cylinder without condensation. If the engine is compound the steam, having lost its superheat at the terminal point of the high pressure cylinder, is resuperheated about 100° in a reheater between the high and low-pressure cylinders and again loses its superheat while expanding into the low pressure cylinder, arriving at the point of exhaust with the temperature of saturation. This arrangement may be considered at the present time as the best which can be proposed. The amount of superheat is so moderate as not to require anything more than good construction for modern high steam pressure.

Highly superheated steam must be treated with more consideration. Engines which will stand a temperature of 500° F. are not necessarily fitted to handle steam at 750°, but these temperatures may be, and have been repeatedly, used successfully.

As shown by many published reports of tests at various points of superheat an increase in temperature is accompanied by a decrease in steam consumption, hence it is worth while pursuing this line. To employ these high temperatures it is at present considered important to use poppet valves on the high-1pressure cylinders at least, as it is here that the full effect of the superheat is felt, and this type of valve is easier to lubricate and does not become distorted with heat. We believe, however, that a Corliss valve may be so proportioned as to operate successfully under even these conditions.

One of the well-known methods of utilizing high superheat is that known as the Schmidt system. This consists in passing a portion of the highly superheated steam directly from the boiler through the reheating tubes of a receiver, between the high and low-pressure cylinders of a compound engine, and then letting this steam mix with that which enters the high-pressure cylinders direct from the boiler. The high-pressure exhaust is thus superheated on its way to the low pressure cylinder while the temperature of the steam admitted to the high-pressure cylinder is modified by its admixture with steam which has already been through the reheater coils and incidentally a receiver drain is unnecessary. Automatic regulation of the superheat to a desirable point in each cylinder, under a varying load, is claimed for this system. Ordinarily an increase of load beyond normal, necessitating a late point of cut off in the high pressure cylinder, will give an excess of superheat in this cylinder, while the reheater will not be sufficiently active to superheat this steam on its way to the second cylinder. With the Schmidt system, however, the effect is reversed by causing a greater amount of steam to pass through the receiver coils where it gives up its superheat to the low-pressure cylinder during periods of heavy draft, and the high pressure cylinder is thus protected from excessive heat. The contrary effect in both instances may be followed through in case of an engine running under a light load.

In the present state of the art it would seem that the condition most attractive to American engine builders would be one of moderate superheat. We thus confine ourselves to a conservative policy and avoid the necessity for making any special provision for extremely high temperature. We use lubricants and gaskets and packing which may be obtained in the open market at a reasonable cost, while at the same time we avail ourselves of such positive and direct benefits of superheating as:

Dry steam in the pipes and throughout the engine.
Elimination of separator.
Low steam consumption per unit of work done.
Smaller steam pipes and ports.
Simplified system of steam jackets.
Greater amount of work done per boiler capacity.
Efficiency at light loads.

These are all practical and common sense improvements, and are of such proportion as to fix our attention.

The absence of water yith the steam need not be dwelt upon. Every practical man will admit that this is of great value. It is further noticeable that a steam pipe system which will show leakage at the joints with saturated steam will become perfectly tight under superheated steam.

The point of maximum economy, while using superheated steam, has by no means been reached. The amount of data available is not in proportion to the extent of the practice. In order to make a comparison between superheated and saturated steam consumption of an engine it is, of course, only fair to place both on a heat unit basis, thus eliminating entirely the question of the cost of the superheat. Assuming a compound engine of about 1,000 HP. and running with 150 lbs. initial and 26-in. vacuum we would consider 12½ lbs. of fuel per indicated horsepower per hour a very good result. We have well authenticated reports of a similar engine, supplied with steam with a temperature of 720° F. at the boiler, consuming less than 9 lbs. of steam per indicated horse-power, or a gain of 39% in economy with an expenditure of but 16% more heat units in the boiler.

The reduction in the size of steam pipes and ports rendered possible by using superheated steam is due to the diminished density of an equal volume as compared with saturated steam as well as from the absence of entrained water. The velocity of superheated steam in pipes should be kept up in the neighborhood of 6,000 ft. per minute. As a rough approximation it may be said that superheating will make a difference of 20% in the size of the steam pipe.

The question of steam jackets on a cylinder, which has occupied so much profound attention in recent years, is quickly solved by the aid of superheated steam, and we see at once the benefit of the jacket disappear as a steam economizer. There seems to be no excuse for retaining them on the low-pressure cylinder, and indeed we have proved by trial that on this cylinder a steam jacket is positively wasteful. We do not think it is clearly proved, however, that they may not still be useful when applied to the high pressure cylinder, even if only for the sake of warming a large engine up preliminary to starting.

The effect of getting more work out of a certain volume of steam is naturally felt in the handling of the boilers and in a reduction in the number of fires necessary to do a given amount of work.

Unexpected results have been frequently obtained by the addition of a superheater to a boiler and a higher evaporative efficiency with the superheater in commission has been shown. This is doubtless due to the increase of the heating surface and the lowering of the temperature of the flue gases. In such cases the saving by superheating is felt in the coal pile to the same extent as in the steam consumption.

On the acceptance test of some vertical compound engines of 1,200 and 2,400 HP. on electric light service in Boston the maintaining of efficiency under light loads was well demonstrated. The feed water per indicated horsepower per hour was 12.54, 12.51 and 12.06 lbs. at full load, three-quarter load and one-half load respectively, while the amount of superheat was 80°, 64° and 48° at the high pressure admission and 60°, 67° and 84° at the low-pressure admission. The engine had reheaters and steam jackets on both cylinders, and it is not unlikely that still better results would have been obtained had the low-pressure jackets been omitted.

It must not be considered necessary to make any very extensive preparations for the use of superheated steam, it may almost be said that the requirements are merely in the line of good practice, and, as such, should be inaugurated in any event. It is important to have the joints of the steam pipes firmly made and well bolted; corrugated brass gaskets are usually found very satisfactory with superheated steam. Provision must, of course, be made for the expansion and contraction of the steam lines to a somewhat greater extent than ordinarily, and the steam pipes, as well as the flanged unions, should be covered with a good non-conducting material in a thick layer. It is important to have the flanged unions covered as well as the pipe.

With proper precautions of this sort and with a velocity of steam in the pipes of from 4,000 to 6,000 ft. per minute, the drop in temperature per foot of run may easily be kept down to 1° in 6 or 7 ft. of length.

Metal of low melting point must, of course, be avoided in the construction of the engine, especially about the valves and piston rods. The stuffing box bushings must be made of metal which will not run under the temperatures likely to be encountered. The metal should be uniformly distributed in designing the valves and cylinders to get the best results with superheated steam, as in this way a uniform expansion by heat is provided for. The barrels of the cylinders are preferably made without projections or ribs. The poppet valve has the advantage in form, but the Corliss valve is also made in such a manner as to expand and contract without warping, and the large number of Corliss engines using superheated steam is a strong evidence of their adaptability.

The lubrication of the cylinders is apt to cause one who has not had experience with superheated steam a great deal of unnecessary anxiety, but really this problem is very simple. It must be borne in mind that the temperature inside of the cylinder is never very high, even when the superheat at the entrance is very considerable, and if the cylinder is lubricated directly without mixing the oil with the steam at the entrance point there can be no possible difficulty. With any reasonably good grade mineral oil, however, it cannot be claimed that any difficulty has been experienced with the lubrication of the parts, even when applied in the ordinary way.

The effect of superheated steam in the indicator diagrams is worthy of notice. Steam being used as perfect gas, the diagram approaches more nearly the theoretical, and, as there can be no re-evaporation in the cylinder the tendency of the pressure to rise during the stroke is absent and the amount of work done in the low pressure cylinder is brought down to the proper point. In designing an engine to be run with superheated steam it will be well to bear this point in mind, as there is danger of approaching the usual constants in the selection of the size of the cylinder, for the reason that the horse-power of the steam used with superheated steam will be nearer the theoretical.

Although there has been less experience in using superheated steam on locomotives, it cannot be said that this field is of minor importance. Trials have been started on the Canadian Pacific Ry., and are now being conducted on the Pennsylvania R. R., which will doubtless contribute much to the knowledge of this subject. In the former instance it was found that by the addition of a superheater a simple engine weighing 204,000 lbs. was enabled to do 60% better in equivalent ton miles hauled per ton of coal than a similar engine without superheated steam, and 30% petter than a compound engine without superheated steam. We should expect better results from a compound engine with superheated steam, and doubtless later experiments will bring out this feature. It is of inestimable importance to railroads if, as is apparently true, that with the same boiler power they are able to use larger cylinders and haul more cars.

Superheated steam is destined to play an important part in the adoption of the steam turbine. Already a number of tests have been published which show a considerable decrease in the steam consumption with the amount of superheating, and it is not difficult to understand that a machine of this type would be greatly benefited, even by the ilimination of moisture and dense vapor from the propelling medium.

ROTARY PUMPS.*

By John T. Wilkin, M. Am. Soc. M. E.†

The writer has been searching diligently for the past 16 years for information about rotary pumps, in order to have the benefit of the experience of others. The greatest amount of information was found in the United States Patent Office records, and in Professor Reuleaux's "Kinematics of Machinery," translated and edited by A. B. W Kennedy, C. E., and published in 1876 by Macmillan & Co., London—a book which has been out of print for some time and is very difficult to obtain. In this work Professor Reuleaux cites records of the use of this pump as early as 1630, the pumps described having two impellers, each of which had four lobes or teeth; and he shows and discusses many forms of rotary positive machines, some of which were intended for steam engines, some for pumps, and other for blowers. This book contains the most comprehensive history and discussion of rotary machines that the writer has been able to obtain.

The development and commercial use of rotary pumps kept pace with the other types until about thirty or forty years ago, when they became quite unpopular, largely due to the fact that they were misapplied, and because the manufacturers undertook to produce them too cheaply in

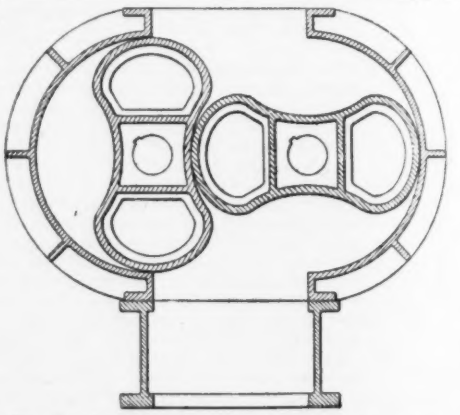

Fig. 1. The Two-Lobe Cycloidal Rotary Pump.

order to compete with centrifugal pumps, making the contact surfaces of the impellers unfinished castings. The misapplication was in using small capacity machines for high pressures, resulting in a large per cent. of leakage and developing weakness of construction.

The writer, after a careful study and analysis of the different forms shown in the above-mentioned records, and also those which were on the market at that time, decided, about ten years ago, that a rotary pump having two similar impellers, the contours of which were formed by complete epi- and hypo-cycloids, would make a machine which would give excellent results if properly constructed and applied. Fig. 1 shows a cross-section of

*Abstract of a paper read at the New York meeting of the American Society of Mechanical Engineers.

†Mechanical Engineer, Connersville Blower Co., Connersville, Ind.

such a pump, which is designated as a two-lobe cycloidal pump, and it is this form which will be principally discussed in this paper.

The writer has proceeded with a belief that a rotary pump is a good device for moving large volumes of fluids at low or moderate pressures, and has avoided using them on high-pressure work. This form was selected for the following reasons, viz.:

The outlines of the impellers are mathematically correct, hence the clearance can be made uniform.

The shape admits of a strong casting in a single piece, thus avoiding internal fastenings or joints.

The impellers revolve freely in their cylinders, hence there is no internal friction, packing, nor necessity for lubrication.

The minor axis of the impeller is large enough to permit the use of a shaft of ample diameter, leaving sufficient metal for a good hub, and at the same time giving a relatively high capacity to a machine having a given distance between the shaft centers.

There is no sudden change of work on these impellers nor in the pump as a whole.

There is no tendency to form enclosed pockets between the impellers in which the fluid would be compressed, causing unnecessary work.

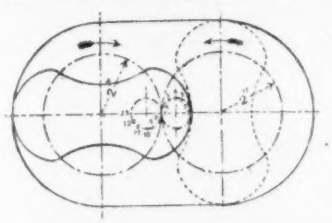

Fig. 2. Showing Dimensions of a Two-Lobe Rotary Pump.

It is a remarkable fact that all of the principal rotary pumps on the market at that time were so arranged that there were two or more points of contact between the impellers in certain portions of the revolution, thus forming compression spaces, the same as in the case of a pair of gears used as a pump. This reduction of volumes when the pump is used for liquids is very destructive in its effect, and was recognized by certain designers, who provided grooves in the end plates connecting these spaces with the suction side of the pump, thus relieving to some extent the shock.

The displacement per revolution of a two-lobe cycloidal pump is exactly the volume of the cylinder in which the impeller revolve, or, in other words, the area of a two-lobe cycloidal impeller is one-half the area of the circumscribed circle. This fact makes it possible for this form to be used as a meter, the displacement of which can be very accurately determined.

The discharge from the pump is continuous but not uniform. One of the errors which has been committed in connection with rotary pumps is that their manufacturers have claimed the discharge to be uniform. Figs. 2 and 3 show diagrams of the path of contact between the two impellers, and the variation of work on each one, also the variation of the combined work of both. The base line in Fig. 3 is a development of the pitch circle, the radius of which in this case is 2 ins. If the length of the impellers be assumed as unity, the capacity of the pump per revolution is represented by the area enclosed between the base line and the line 2¼ ins. above. The dotted curved line in Fig. 3 represents the variation of work of the impeller shown in dotted lines in Fig. 2, while the lower full-curved line in Fig. 3 represents the work of the opposite impeller. The upper curve represents the combined work of both impellers. The distance between the ordinates represents the travel at the pitch line, also the travel of the point of contact in the circumference of the small generating circles. This diagram was made to determine the amount of water which must be absorbed and given off by the air chambers when the pump is used on liquids and the areas between the upper curved line and the line of mean discharge enable us to determine this quantity. It will be noticed that the point of maximum discharge is ten-ninths and the point of minimum discharge is eight-ninths of the mean discharge. The work on each impeller varies from zero to a maximum shown 2 ins. above the base line. The minimum work of the pump occurs when the impellers are at right angles to each other, as in this position one impeller is balanced and the opposite one is at its point of maximum work. The position of maximum combined work of the two impellers is when their major axes are parallel to each other and at angles of 45° to the line of centers.

Assuming one of the shafts to be the driver, the work transmitted by the gears varies with the work of the driven impeller. The maximum gear transmission, therefore, is eight-ninths of the mean work of the pump.

The area which each impeller presents to the working pressure is variable, as is also the direction of the resultant pressure, the maximum area of the impeller being exposed to the full difference of pressure, under which the machine is working, when the major axis of the impeller is parallel to the line of shaft centers. The points of contact with the cylinder and with the other impeller are on the center line at this point, and the impeller is in a balanced position doing no effective work, so that in this position the total load due to the pressure, plus the weight of the moving parts, is downward or at right angles to the line of centers. As the impeller leaves this position the direction of pressure and the exposed area vary until the impeller reaches a position at right angles to the line of centers, where it has its maximum unbalanced area exposed, and also where it undergoes a change in direction of pressure, due to the passing from suction to the discharge, of the inclosed volume of fluid between it and the cylinder.

In designing rotary pumps one of the principal problems to be solved is the proper provision for supporting the impellers. They are supported by their shafts resting in journal bearings separated from the cylinders by stuffing boxes; hence, the problem is a modification of the beam supported at the ends and carrying a load varying in intensity and direction, the load being distributed over a portion of its length. This problem can hardly be solved by any other method than experience, but when properly solved the rotary pump has proven itself to be an excellent device for moving large volumes of fluids against moderate pressures. The designer of rotary pumps is not compelled to consider a multiplicity of valves, ports, etc., such as is met with in the design of reciprocating machinery, nor does he have the problem of velocities, centrifugal force, fluid friction, accurate balancing, etc., as encountered in designing centrifugal machines.

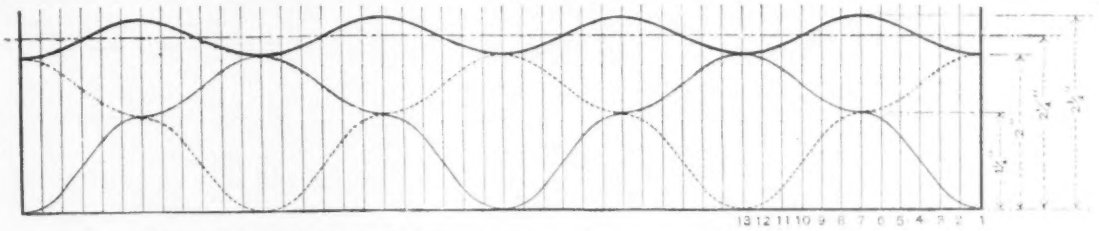

FIG. 3. SHOWING THE PATH OF CONTACT AND THE WORK OF THE IMPELLERS OF A ROTARY PUMP.

We have up to this time used the word pump in its broader sense, but in considering the uses of rotary pumps the machines used for elastic fluids should be discussed apart from those used for liquids. The action of a rotary pump or blower as an air compressor is practically the same as the action of a duplex, crank-and-fly-wheel, double-acting, piston compressor which has mechanically operated valves opening and closing at the beginning and end of the stroke, assuming the piston machine to have no clearance spaces. There is, therefore, no gradual compressing of air in a rotary machine, and the unbalanced areas of the impellers are working against the full difference of pressure at all times. The possible efficiency of such a machine under ordinary temperature and conditions of atmosphere, assuming no mechanical friction, leakage, nor radiation of heat or compression, would be as follows:

Compression to	1	pound	gage	pressure	97½%
" "	2	"	"	"	95½%
" "	3	"	"	"	93 7/10%
" "	4	"	"	"	91 7/10%
" "	5	"	"	"	90%
" "	10	"	"	"	82 7/10%
" "	15	"	"	"	76 7/10%

Regardless of the above facts, concerning the efficiency of this type of machine as an air compressor, a manufacturer recently issued a catalogue, from which the following paragraph is taken:

The machine illustrated (patent pending) is constructed to stand a pressure of from fifteen to twenty pounds per square inch. In this machine we use a spray of water to pack the machine and prevent backward escapement of air, and at the same time absorb the heat caused by compression. The water is carried over into the separating tank and automatically drained off. This new device, after careful and exhaustive test, proves to be all that we expected of it, and enables us to maintain fully as high an efficiency under high pressures as we can under one pound or less. For work where a pressure of from two to eighteen pounds is required, we are ready to guarantee a very high efficiency. We contend that the principle of the rotary motion applied to air under high pressure eliminates a vast amount of friction, and hence wear and tear; and when high efficiencies can be obtained, is preferable in every respect to the blowing engine.

This reference is quoted to support the position taken—that a machine, when misapplied, cannot be made successful, and such a policy is sure to bring it into bad repute.

We consider a rotary machine of this type out of place when working in elastic fluids at more than 5 lbs. difference of pressure. The proper application of rotary positive machines when operating in air or gas under differences of pressures from 8 oz. to 5 lbs. is where constant quantities of fluid are required to be delivered against a variable resistance, or where a constant pressure is required and the volume is variable. These are the requirements of gas works, pneumatic-tube transmission (both the vacuum and pressure systems), foundry cupolas, smelting furnaces, knobbling fires, sand blast, burning of fuel oil, conveying granular substances, the operation of many kinds of metallurgical furnaces, etc.

The efficiency of a rotary pump depends on the size, the speed at which it is operated, the pressure under which it is working, and its construction, while the capacity varies as the square of the diameter of the cylinders, or distance between gear centers, and directly with the length of the impellers and cylinders. The principal leakage lines are the contact lines between the impellers, and between the impellers and cylinders, as the impellers can be fitted quite closely at their ends. It is obvious, therefore, that in a large machine the per cent. of slip due to the working pressure and the clearances is less than in a small one. For example: One blower has a capacity of 12½ cu. ft. per revolution, its shaft centers are 16 ins. apart, and its impellers 48 ins. long; another has dimensions just twice these, and its capacity is 100 cu. ft. per revolution, or eight times as great. If we assume the machines to have the same clearances, and running under the same speed and pressures, then the per cent. of slip in the larger machine would be only one-fourth that of the smaller, because the leakage lines are twice as long in the larger machine and its capacity is eight times the smaller one.

Since the leakage lines are exposed to the working pressure at all portions of the revolution, the slip is practically constant for a given pressure whether the machine be running fast or standing still. This argues for as high a speed for a blower as is consistent with successful mechanical operation, because the loss due to air friction is inconsiderable if the inlet and discharge are made large. For water, however, questions of velocities are very important, and the speed should be reduced. The theoretical weight of a cubic foot of air at one pound above atmosphere and at a temperature of 62° Fahr. at sea level is .076 lb. The height of a column of air of equal density necessary to produce a pressure of one pound per square inch would be 1,895 ft. If $V = \sqrt{2g\,H} = 8.02\,\sqrt{H}$, then the theoretical flow at the base of the column would be 8.02 times the square root of 1,895, or 349 ft. per second, and for small differences we assume that the velocity varies as the square root of the pressure. Therefore, doubling the pressure doubles the load, and increases the slippage to 1.41 times what it was at the original pressure. We have found the above assumptions concerning the slippage in rotary blowers to be practically correct, after having tested hundreds of them by closing the discharge and counting the number of revolutions of slippage at different pressures.

An interesting experience was had with two pumps, each to have a capacity of 25,000 gallons per minute lifted 31 ft., coupled direct to a Corliss engine, running at about 67 revolutions per minute. We designed them with two air chambers on the discharge and two on the suction side of the pumps, placing them as near as possible to the impellers, the air chambers having connections to the pumps 7 ins. in diameter. When we began to operate the pumps we found that they would run smoothly up to 50 revolutions per minute, at which speed a powerful water hammer occurred. We attached an indicator to the discharge side of the pump, 18 ft. below the upper water level, and found that the pressure there varied from 5 or 6 lbs. vacuum to 30 or 40 lbs. pressure. The action on the suction side was similar except that the vacuum was about 12 lbs. and the pressure rose slightly above atmospheric pressure.

It was this experience which led to the production of the diagram shown in Fig. 3. It also caused the writer to investigate the practice concerning air chambers on piston pumps, and we were surprised at the abuses committed by the users of that type of pumps. Mr. F. Meriam Wheeler has brought this matter out very clearly in one of his papers,* and it would be well if manufacturers and users of reciprocating pumps would follow his advice.

We corrected the deficiency in capacity of air chambers on the above-mentioned pumps by the addition of more chambers which enabled us to operate the pumps at a speed of 85 to 90 revolutions per minute.

Since then we have made pumps having capacities of 35,000, 40,000 and 50,000 gallons per minute, which are operating under heads of from 8 to 25 ft., and have had no trouble from water hammer.

The writer has taken many indicator cards from engines operating rotary pumps, and finds the combined efficiency of the pump and engine to be from 80 to 84%.

Two large pumping plants are now under way near Beaumont, Texas, for the Treadway Canal and Rice Co., from which we expect to get some excellent records, one

*Trans. Am. Soc. M. E., Vol. xxii., p. 439.

plant consisting of four 35,000 gallon pumps, operating under 35 ft. head, direct coupled to compound condensing Corliss engines; the other plant consisting of two 70,000 gallon pumps, operating under 10 ft. head, direct coupled to tandem compound condensing Corliss engines. These plants are to be operated with oil fuel, and we hope to be able to make accurate duty tests of them and place the records of these tests before the engineering world.

MONIER CONCRETE-STEEL STORAGE TANKS FOR PORTLAND CEMENT; ILLINOIS STEEL CO.

The Portland cement department of the Illinois Steel Co. has had built at its cement works in South Chicago, Ill., a storage plant of four cylindrical concrete-steel bins or tanks constructed on the Monier system. The total capacity, including the central space between the tanks, is 25,000 barrels.

The tanks are 25 ft. diameter inside, and 29 ft. c. to c., the space between each pair of adjacent walls being closed by a cylindrical shaft 30 ins. diameter, and the entire structure being monolithic. The foundation is a continuous floor or bed of concrete 3 ft. thick, 66 × 66 ft., with corners of 18 ft. 6 ins. radius. About 5 ins. above the base of this is embedded a netting of 9-in. mesh formed by ⅝-in. round steel rods, tied together at their intersections by No. 18 wire. Upon this concrete bed is a series of piers 12 ft. 6 ins. high, and 1 ft. 10 ins. thick. Those near the outer circumference of the tanks are mainly 3 ft. 5 ins. long, but others near the central portion are from 6 ft. 8 ins. to 7 ft. 10 ins. long. All the smaller piers have four steel rails embedded in the concrete, the rails being connected by spacing bars riveted to them, and resting on ½-in. steel plates embedded in the concrete floor about 15 ins. below the surface. The piers are capped with similar plates. The larger piers have six or eight rails. Upon the piers rest concrete-steel girders 15 ins. deep and 4 ft. wide, with vertical openings at intervals for the discharge spouts. Through each girder run four horizontal lines of steel rods near the top, and four other lines bent to form truss rods, with sheets of wire netting on each side of each pair of rods.

The cylindrical tanks, 53 ft. 6 ins. high, rest upon this system of girders, the base being 13 ft. 9 ins. above the level of the concrete floor. The walls are 7 ins. thick in the lower part and 5 ins. in the upper part, the thickness being increased where they unite with the circular walls which close the spaces between the tanks. Within the concrete walls is embedded a continuous sheet of netting of No. 9 wires electrically welded at their intersections and forming rectangular meshes 1 × 4 ins. Around this (and alternately inside and outside of it) are horizontal rings of rods 4 ins. apart, tied to the netting by wire. These rods vary from 1 in. diameter near the base to ⅜-in. near the top, while the top is finished with a ring formed by a 5-in. Z-bar. The roof is conical, 2 ins. thick, with a manhole at the edge and an opening at the top for the spout. It was thought that with a hopper bottom and central discharge, material such as cement would give trouble by bridging, and the bottom is therefore made conical, with eight discharge openings in the annular space between the base of the cone and the side of the tank. These openings are about 15 × 48 ins., and each serves two spouts leading to conveyors which carry the cement to the packing and shipping department. The conical bottom is 4 ins. thick, reinforced with rods and netting, and its diameter at the base is [illegible]. The concrete in the foundation floor and piers is composed of 1 part Portland cement and 3 parts coarse sand, and 4 parts stone. That of the tanks is composed of 1 part Portland cement [illegible] parts sand, no stone being used. It was mixed moderately wet and lightly rammed in wooden forms. These forms were constructed of [illegible] planks 3 ft. long, kept together by means of the horizontal angle irons supported by vertical angle irons clamped together above the wall. The concrete was poured in and tamped inside the forms which were raised in 45° sections, 28 ins. high every 24 hours. The work was carried on by day and night so as to prevent any setting between the layers of concrete.

The cement is brought from the mill by a horizontal screw conveyor and delivered into the boot of a vertical bucket elevator, which again delivers it to a horizontal screw conveyor above the tanks by which it is carried to the spout of one or other of the tanks. The elevator runs in a rectangular shaft 12 × 14 ft., and the distributing conveyor in a chamber or housing 10 ft. 3 ins. × 12 ft. 4 ins., supported by a steel bent. The shaft and housing are built of a framing of steel angles, sheathed with Monier concrete-steel plates 2 × 5 ft., ⅝-in. thick, made of cement mortar and wire netting. The floor of the conveyor housing is of similar plates 1 in. thick.

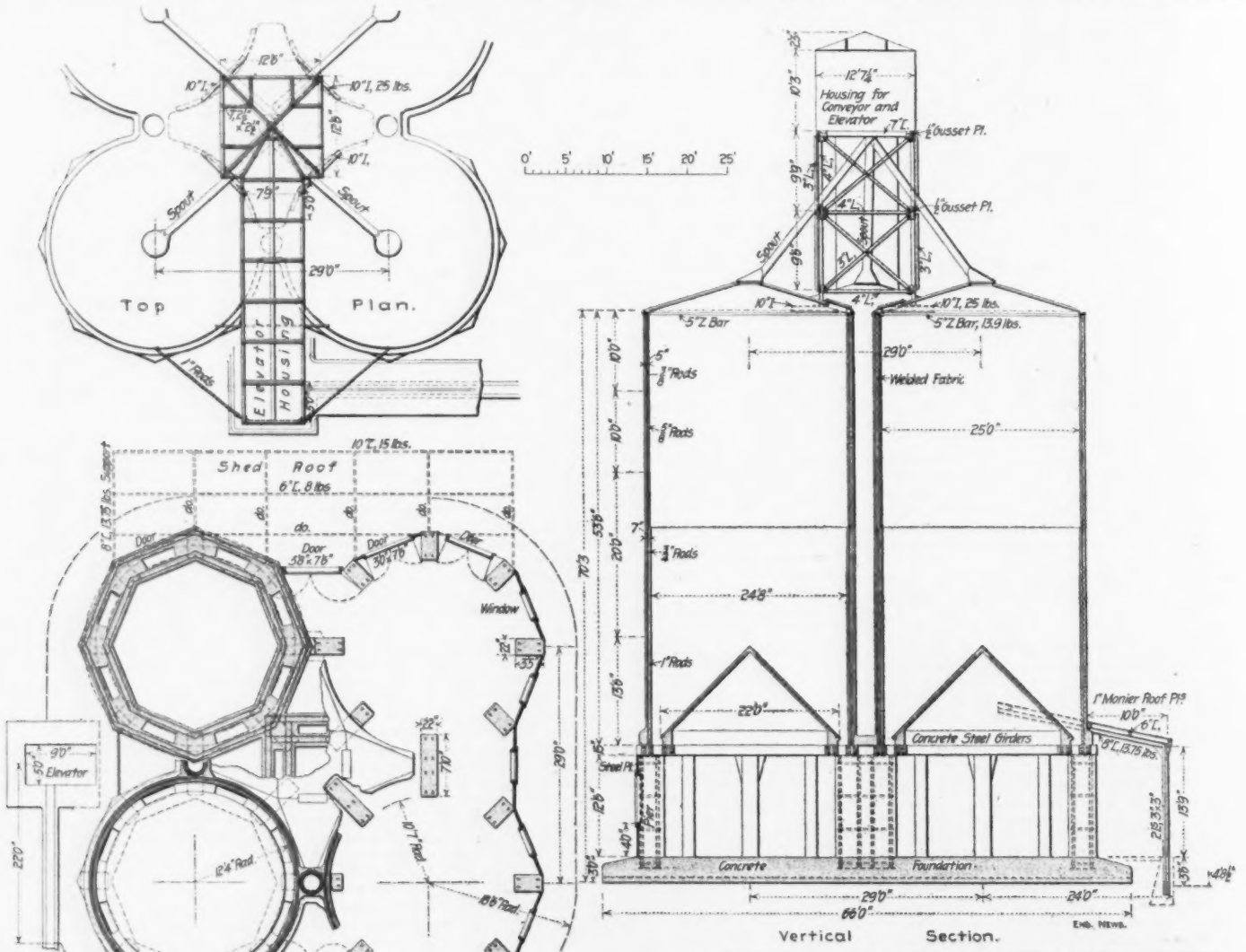

FIG. 1. CEMENT STORAGE BINS OF MONIER CONCRETE-STEEL CONSTRUCTION FOR THE ILLINOIS STEEL CO. (CEMENT DEPARTMENT).

E. Lee Heidenreich, Contractor, Chicago.

This structure was designed and built by Mr. E. Lee Heidenreich, M. W. Soc. C. E., Contracting Engineer, Rookery Building, Chicago. Mr. Heidenreich is agent for the Monier system of concrete-steel construction in this country, and to him we are indebted for plans and other information.

BITUMINOUS MACADAM PAVEMENT ON MAIN ST., EVERETT, MASS.

Main St., in the city of Everett, Mass., was laid out by the county commissioners in 1873. It has a maximum grade of 2.73% and a subsoil of clay and hardpan. The street was macadamized a number of years ago, but the traffic has increased to such an extent that it has become impossible to maintain macadam in good condition for more than one year without resurfacing. The street is one of the main highways from Boston to Malden, Melrose and other cities and towns, and teams weighing 10 to 20 tons pass over it daily. In addition, the Boston Elevated Railway passes two lines of surface cars over its tracks every ten minutes.

A bituminous macadam pavement is now being laid outside the rails on a length of 2,000 ft. of street by the Warren Bros. Co., of Boston, Mass. The two lines of railway occupy 14 ft., out to out of rails, and there is a header course of 12-in. blocks on a concrete base just outside the rails. This leaves 13 ft. on each side of the tracks, between the stone blocks and the curb, for the bituminous macadam. The contract price for the work is $2 per sq. yd., including a maintenance-guarantee period of five years, with a surety company bond. The price named covers excavation to subgrade, 6 ins. below the finished pavement; removal of the excavated material to a distance of not over one mile, rolling the subgrade with a 20-ton roller, furnishing grade stakes and all other supplies, repairing manholes and connecting up at street intersections, and laying the pavement. The stone headers are laid on 9 ins. of concrete, have cement grout joints, and are measured and paid for at $2 per sq. yd., the same as the bituminous macadam. The portion of the specifications relating specifically to the bituminous macadam are as follows:

On top of this sub-foundation shall be laid a layer of hard-crushed stone 4 ins. in depth after compression. This shall be coated after being thoroughly compressed with a heavy steam roller, with a thin layer of Warren's No. 1 Bituminous semi-liquid composition (Puritan brand), said bitumen to be sufficiently flexible to unite freely with the cold stone.

On top of this No. 1 composition shall be spread a heavy coating of Warren's No. 24 Puritan brand hard macadam bituminous cement, for the purpose of firmly binding the foundation together and making it readily unite with the bituminous concrete wearing surface.

On this prepared foundation shall be laid the wearing surface or pavement proper, which shall be composed of carefully-selected, sound, hard-crushed stone, ranging in size from 2 ins. in diameter to an impalpable powder, mixed with sand and containing all sizes and grades, so that the mineral aggregate shall contain the least possible amount of voids. The proportion must be determined by special laboratory examination of the ingredients to be used.

After heating the stone, preferably in a rotary mechanical dryer, to a temperature of about 250°, the stone shall be passed through a rotary screen, to enable proper proportioning and measuring of the several sizes, and thus separated into at least four sizes, each of which shall contain the proper proportions of particles between its maximum size and the largest particles passing the next finer screen. Each grade of the mineral aggregate selected and mixed as above shall be thoroughly coated and surrounded with Warren's Puritan brand No. 19 bituminous macadam composition, using a sufficient quantity of said composition to not only thoroughly coat the particles, but to completely fill all voids in the mineral aggregate.

The mixing of the carefully-measured stone of several sizes and the bituminous composition shall be done at a temperature of between 200° and 250° F. in a "twin pug" mechanical mixer, and the mixing continued until the combination is a uniform bituminous concrete. In this condition it shall be hauled to the street and there spread on the prepared foundation to such depth that after thorough compression with a steam road roller it shall have a depth of 2 ft.

After the rolling of the wearing surface there shall be spread over it a thin coating of Warren's quick-drying bituminous flush coat composition, the purpose of this being to thoroughly fill any unevenness or honeycomb which may be on the surface of the coarser mixture. Fine sand is then worked or squeegeed into the surface until all surplus flush coat composition has been taken (or dryed) up by it, and all surplus sand is then removed with stiff brooms.

There shall then be rolled into the surface a thin layer of ½-in. to ¾-in. stone chips for the purpose of presenting a gritty surface which will not be slippery. Each layer of the work shall be kept as free as possible from dirt, so that it will unite with the succeeding layer.

The bituminous composition or cement shall in each case be free from water, petroleum oil, water gas or process tars, and shall be especially refined with a view to remove the light oil, naphthalene, and other crystalline matter, susceptible to atmpospheric influences. If the fine-crushed stone used does not provide the best proportions of fine-grained particles, they must be supplied by the use of hydraulic cement, pulverized stone, or very fine sand.

Mr. Christopher Harrison is city engineer of Everett, and we are indebted to him for the material used in preparing this article.

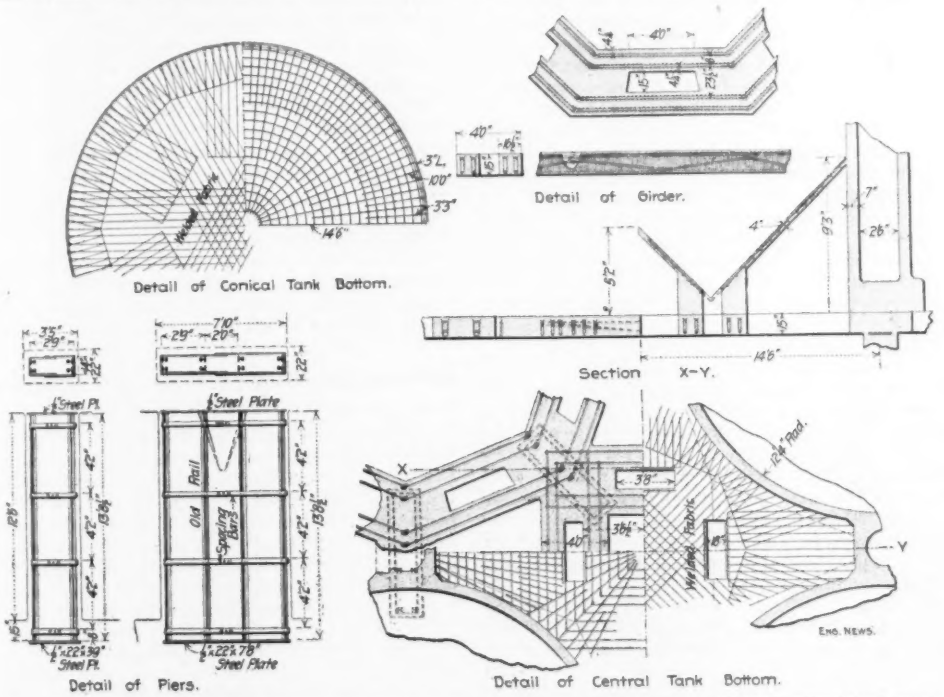

FIG. 2. DETAILS OF MONIER CONCRETE-STEEL CONSTRUCTION FOR CEMENT STORAGE BINS, ESPECIALLY SHOWING ARRANGEMENT OF STEEL WIRES AND BARS.

MALLEABLE CAST IRON.*

By H. E. Diller.†

Much has been written of late in the way of calling attention to the rapid growth of the malleable casting industry, and, indeed, not only are new works springing up in the large iron centers, but the older establishments are expanding very materially. There is little wonder at this when it is considered that the malleable casting is peculiarly adapted to the requirements of four great classes of work; agricultural implements, railway supplies, carriage and harness castings, and pipe fittings. Were it not for the fact that malleable cast iron is not adapted to the heavier sections, it would be a sharp competitor to the gray casting industry.

In its manufacture the special make of iron called "malleable bessemer," or "malleable coke iron," is the principal material used. The charcoal irons, though unequalled for value, are confined to the regions where they can compete with the cheaper coke irons. The silicon should be .75 to 1.50%, phosphorus under 0.200%, while sulphur should be below .04%, if possible. A pig iron, higher in sulphur, in reality an "Off-Bessemer," while meeting the silicon specifications perfectly, should not be used except in limited quantity, and then carefully watched.

With the pig iron, hard sprues (unannealed scrap), steel and also malleable scrap is charged. The latter two materials are very good to add to the mixture as they raise the strength of the casting very considerably. Care must be taken not to add too much, as this reduces the carbon to a point where fluidity and life in the melted metal is sacrificed.

"Malleable" is produced in the cupola, the reverberatory furnace, and the open hearth. The first process, under ordinary conditions, is the cheapest. The iron made is, however, by no means the best. Test bars made of cupola iron seldom run above 40,000 lbs. per sq. in., while with furnace iron there is no difficulty in getting a few thousand pounds more. The most serious objection to cupola iron is its poor behavior under the bending test, the deflection being very light.

In the reverberatory and in the open hearth, the fuel is not in contact with the metal and the result is much more satisfactory. The metal in these furnaces may either be caught in the ordinary hand ladles or it is tapped into a large crane ladle and conveyed to the distributing point and there emptied into hand ladles as required. When tapped into hand ladles, the time taken is a serious item, for the beginning and the end of the heat will be two different things. The latter iron especially will be inferior, as it was subjected to the oxidizing effects of the flame much longer than the first part. As a rule this difficulty is somewhat remedied by pouring the light work first, the heavier pieces coming later, when the silicon has been lowered too much for good light castings. With the crane ladle pour the molder has much less space to travel over, and this will doubtless be the coming method.

It takes a good man in the foundry as well as in the pattern shop to handle malleable casting questions properly. The gating should be done to avoid the shrinkage effects as much as may be, while the little tricks that can be applied make a surprising difference in the molding loss. As a consequence some malleable works seldom lose more than 10%, while in others 20% and over is the rule.

After the castings have been tumbled they go to the annealing room, where they are packed in mill cinder or iron ore, in cast-iron boxes. These are carefully luted up, and heated up in suitably constructed ovens for the space of five or six days. It usually takes 36 to 48 hours to get the oven up to heat, the temperature ranging from 1,600° to 1,800° F. in the oven, the boxes having a somewhat lower temperature at the coldest point. When the fire is extinguished, the dampers are closed tight, all air excluded and the oven allowed to cool very gradually, often but 400° F. the first day. After the castings come from the anneal, they are again tumbled to remove the burnt scale, and they are chipped and ground for shipment.

The hard casting should have its carbon practically all in the combined state, while annealing process should convert this to the so-called temper, or annealing carbon. A well annealed casting should not have much over .06 to .12% combined carbon remaining in it. Under-annealed castings can be readily detected by their brittleness, but it takes much experience to be sure that a casting is over-annealed. There is a material difference between the strength of an over-annealed casting and a normal one. I took two bars from each of five heats. One bar from each set I gave the usual anneal; and the others I re-annealed. The average tensile strength of the first set was 50,520 lbs. per sq. in., and the average elongation was 0¾% in 6 ins. The re-annealed set had an average tensile strength of 43,510 lbs. per sq. in., the average elongation being 6¼% in 6 ins. Over-annealing had therefore cost the metal some 7,000 lbs. of its strength.

The fact that malleable castings are little understood may account for the limited way in which they are specified. While some railways specify the mixture, composition, and strength of gray castings, they do little in the way of the malleable. One railway for which I made castings called for 40,000 lbs. per sq. in., and an elongation of 5% in 2 ins., for sections ½-in. and under, and 30,000 lbs. per sq. in. with a corresponding elongation of 2½ ins. for section ¾-in. to 1 in. thick.

To show to what degree some foundries are making iron for these demands, I took test pieces from some of their castings. The tensile strength and elongation, in 6 ins. of these pieces was as follows:

No. 1.	35,030 lbs. per sq. in., and	4.7%	elongation.
" 2.	34,410 " " " " "	3.3%	"
" 3.	37,840 " " " " "	4.2%	"
" 4.	45,550 " " " " "	4.0%	"

It was also rather odd that the thicker pieces showed the better iron, for usually founders err in the pouring of heavy castings with mixtures intended for light work.

"Malleable" can be made up to 60,000 lbs. per sq. in., though this is not advisable as the shock resisting qualities are sacrificed. Yet as specifications become more severe the general quality of this class of castings will be improved until we get a more reliable article, and which can better resist the encroachments of the steel casting.

*From the "Journal of the American Foundrymen's Association."

†Chicago, Ill

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ADVERTISING RATES: 20 cents a line. "Want" and "For Sale" notices, special rates, see page XXIV-XXIX. New copy for standing advertisements should be received one week in advance of publication; new advertisements, Monday morning. The pages containing "Want," "For Sale" and "Proposal" advertisements are held open until Wednesday noon.

A serious defect in the third-rail system of electric traction is the collection of snow, sleet or ice on the third rail, and the resulting interference with traffic. The Chicago elevated lines have had numerous tie-ups due to troubles of this sort, and the Manhattan elevated lines in New York city had their first experience of a similar sort during the storm of Dec. 5. Those parts of the system where electric trains are run exclusively were for a time more completely tied up than they have been since the famous blizzard of 1888. It is stated that devices are to be fitted to the motor cars to clear the contact rail of ice in advance of the shoe, and that after this is done no further trouble will be experienced. This is very likely true as regards ordinary storms, but the time of trial comes when rain falls on rails below the freezing temperature and the rail becomes coated with an icy plating as smooth and almost as hard as glass, which almost defies the power of mechanical devices to remove. It is doubtful whether there is any effective remedy for this condition except roofing over the third rail, and there are objections to doing this.

A graduate school of engineering research is to be opened next year at the Massachusetts Institute of Technology, according to a published announcement of President Pritchett, and it is stated that the work of the school will be directed toward the solution of problems of immediate practical importance. Funds are to be provided to carry on the investigations; one donation already made being the sum of $5,000 a year for three years to investigate methods of sewage disposal for large cities. For the benefit of students in this department, there are to be six fellowships of $500 a year each which carry with them also exemption from tuition fees. It is proposed that graduates from the school shall receive the degree of "Doctor of Engineering;" but we trust that wiser counsels will alter this. To give such a degree to graduates from an engineering school—even though it did post graduate work—would be on a par with turning out young theologues as "D. D.'s" or graduates from a law school as "L. L. D.'s." If the degree of Doctor of Engineering is to be used at all, it should be reserved as an honorary degree for those men of advanced years who have already such professional distinction as to give the title real value and significance.

The Interstate Commerce Commission has done wisely in ordering an investigation of the general increase in rates on freight transportation by rail which has been undertaken by a number of the leading railway companies. It is true the Commission has largely been shorn by the courts of its power to directly control the railway companies; but it still has the power to investigate and compel publicity; and this power will be well exercised in drawing public attention to the increase in rates and to the arguments for and against it.

Current published statements have set forth the increase in the cost of living and of supplies during the past few years, and the consequent necessary increased expenditures of the railways for wages and for materials, as the reasons which they will urge in defence of the advance in rates. The validity of these arguments is admitted; but it is proper also to inquire whether the growth in volume of traffic which has taken place has not furnished an increase in gross earnings sufficient to overbalance the growth in expenses. Good evidence that this is the case appears to be furnished by the steady increase in net earnings reported by most railway companies.

The fact needs to be emphasized in this connection that railway rates should conform to the laws governing monopolies, and not to those in which free competition prevails. A railway is not entitled to charge "what the traffic will bear." It is entitled to charge enough so that its total revenue will be sufficient to pay its operating expenses and fixed charges, and in addition a reasonable—and no more than a reasonable—return on the money actually invested, due consideration being given to the risks involved.

There is a general impression that during the past two or three years railway security-holders have been receiving a very fair return on their investments. If now it is proposed to shove up freight rates to increase these returns in order to pay dividends corresponding to the prices to which Wall Street speculators have advanced prices of railway stocks, or to pay dividends on the water which has been so liberally poured in in connection with some of the recent reorganizations and consolidations—if that is the purpose of the increase in freight rates, the public protest cannot be too emphatic.

We commend to the consideration of street paving advocates the following extract from the Portland, Oregon, "Oregonian" of Nov. 29. Evidently there is work for "good roads" advocates to do in some of our western cities without going outside the city boundaries:

> A big two-horse delivery wagon was mired in the mud at the corner of 25th and Thurman streets yesterday afternoon. The running gear of the vehicle went out of sight, except the tops of the wheels. The wagon-bed rested on the surface of the mud. The team was hastily unhitched and taken out of the mire with some difficulty, and residents of the vicinity came to the aid of the mud-wrecked craft and assisted with the delivery of packages remaining aboard when she went down. But the wagon defied all efforts at rescue for some hours. Finally, late in the evening, a pontoon that would stand the service was erected around the vehicle, jackscrews lifted it from the murky depths, and by means of long-distance towing it was gotten to solid ground again.

Some ten years ago an attempt was made to establish some sort of official connection between the American Society of Civil Engineers and the local engineering societies in various parts of the country. The attempt resulted in failure. The opportunity to develop on broader lines, however, has been taken by the youngest of the four national engineering societies, the American Institute of Electrical Engineers. For years it has held local meetings at Chicago, in addition to its meetings at New York, and it has recently established local meetings also at Pittsburg. Besides this it proposes to hold branch meetings at a number of the principal technical schools. On Nov. 25 the first meeting at the University of Illinois was held, and papers presented at the regular October and November meetings of the Society were read and discussed by students in electrical engineering.

The American Society of Mechanical Engineers is also moving—or getting ready to think of moving—in a similar direction. At the annual meeting last week it was announced that one of the subjects under consideration by the committee which is revising the society's constitution is an amendment enabling the Society to hold sectional meetings—either geographical or professional—in addition to its regular semi-annual meetings.

This movement is of considerable interest in connection with the strong plea made by Mr. Chas. F. Scott, at the Philadelphia Engineers' Club dinner last week, for coöperation between the great national engineering societies. If local sections are to be established by these societies, something in the way of coöperation and federation appears inevitable. It would be in the last degree foolish to create in such a city as St. Louis for example, separate local sections representing each of the four national engineering societies, each with a separate headquarters and organization staff. Financial considerations alone would make it impossible.

As for Mr. Scott's statement that petty jealousies between the societies are unworthy of the engineering profession, we take it that no argument is necessary to prove its truth.

THE AMORTIZATION OF A CONTRACTOR'S PLANT AND ALLOWANCE FOR PROFITS.

In looking over items of cost data of engineering work as made by engineers, one is struck by the fact that the item of interest and depreciation of plant is often entirely omitted, or, if inserted, is ridiculously small. It is not unusual to see 6% of the cost of the plant allowed on a per diem basis, with the implied assumption that the plant is working every day in the year and every year forever. Stated thus bluntly, the absurdity is evident, but as contractors are themselves very apt to underestimate the charge that should be entered for plant wear and tear and interest, we shall briefly consider the matter. In the first place, a rate of interest equal to the legal rate is too low. On a large and steady earning plant like a railroad, for example, upon which money can be borrowed from banks almost up to the full value of the plant, it is proper to charge only the legal interest rate; but on a contractor's plant it is ordinarily difficult to borrow much if anything at all. Under such conditions a contractor will estimate the interest rate on his plant at what he would consider a fair profit on the capital so invested if he had used that capital in other parts of his business, as, for example, in payrolls, payment for materials, etc. His profit is seldom estimated at less than 15%, hence the interest rate on the capital invested in plant should be 15%; but this is a per annum rate, whereas a contractor's plant is ordinarily busy but a comparatively few days out of the 365. Assuming 60 days as a fair average for a roller, we see that

$$\frac{\$2{,}000 \times 15\%}{60} = \$5.$$

Thus the real per diem interest charge against the plant, which, for a $2,000 roller, is about $5 per actual working day for interest alone. To this must be added the charge for depreciation. A roller has an unusually long life for a part of a contractor's plant, say 20 to 30 years, before it will probably be necessary to substitute a more modern tool. Repairs to flues and movable parts will seldom be less than $60 per annum, or $1 per day worked, while an equal amount set aside as a part of the amortization fund may be assumed as a fair average, thus making the total

charge per day actually worked on a basis of 60 days per annum:

Interest	$5.00
Repairs	1.00
Sinking fund	1.00
Total	$7.00

Does this seem high? Test the accuracy of the figures by trying to rent a roller for an ordinary short piece of road work.

Contractors entering upon work new to them almost invariably underestimate the charge that should be made against the plant; and at the end of the work often find that their sole profits are represented by the plant itself, which, not infrequently, they never use again. It is, therefore, not unusual for experienced contractors to charge the full cost of a plant to the particular contract upon which they propose using it. Not infrequently they fail to be the lowest bidder in consequence, but they often have the satisfaction, grim though it be, of witnessing the bankruptcy of their successful (?) competitor. Engineers in estimating the cost of work should never fail to estimate liberally the cost of plant, and we may in this connection say that the addition for profits should ordinarily be more than the customary 15%. There are many classes of business which are infinitely safer risks than contracting, wherein more than 15% on the total business done is annually earned. Not infrequently more than 15% is added to the cost of goods in making the selling price, and the capital invested is turned over so many times during the year that after deducting fixed charges there is a net profit far in excess of 15%. Most classes of engineering work can be done only during a few months of the year, which makes it further apparent why contractors' profits must be larger to cover the idle months. We may say as a general rule that 15% may be safely added to the cost of materials delivered at the work, but that for the labor item at least 25% profit should always be added. It is not only more difficult to figure the labor item beforehand, due to variations in character of work and of laborers in different localities, but there are the elements of chance to be considered, such as strikes, delays from bad weather, during which fixed charges remain undiminished, and accidents to men.

A careful contractor usually insures his men, and for ordinary risks pays about 1% of the payroll. Sewer work, for example, is a risk that in some cities insurance companies will not take.

It is the duty of the engineer to estimate liberally rather than to run "close to the handle," for he thereby will often save inexperienced contractors from bidding foolishly low, and will not discourage experienced contractors from bidding at all—a condition that more frequently exists than is commonly supposed. Moreover, underestimating the value of work brings greater discredit upon the engineer than does overestimating, so that if one is not absolutely sure of his data he had better err on the side of safety.

AGAINST THE METRIC SYSTEM.

The strongest argument against the adoption of the metric system which has ever been presented was made in a paper by Mr. F. A. Halsey, read last week at the annual meeting of the American Society of Mechanical Engineers. In another part of this issue we present as full an abstract of Mr. Halsey's paper as space will permit. Even this, however, by no means does full justice to Mr. Halsey's argument, as his paper with appendices covers nearly 66 pages of the Society's "Transactions." We urgently counsel any of our readers who still favor the metric system—or rather the pending legislation for its compulsory use in the government business—to obtain from the Secretary of the Society of Mechanical Engineers a complete copy of Mr. Halsey's paper and give to it the careful reading which it deserves.

The point which Mr. Halsey sets forth most clearly and which we never remember to have seen stated before is that the real difficulty in the adoption of the metric system hinges on the measures of length. The change from pounds to kilograms or from gallons to liters is a trifling matter, involving comparatively little difficulty; but measures of length, as Mr. Halsey tersely says, "are tied irrevocably to the past." Of course it is theoretically possible to make the change from the inch to the millimeter; but such a change means the destruction of existing standards, and to quote again Mr. Halsey's forcible language: "The man does not live who can estimate or indicate in words the value of mechanical standards to this country."

Probably any fair estimate of the reasons for the great success of the United States as a manufacturing nation would have to include as a very large factor the adoption of mechanical standards to a far higher degree than any other country in the world. This adoption of standards has been possible on this continent as it has not in Europe because of the absence here of national and racial boundary lines and tariff walls.

For a familiar illustration take the interchange of freight cars, under which a car may travel from Maine to California, or from Mexico to Canada without transferring its load. This interchange has been made possible only by the existence of widely-adopted standards which make possible the economical repair and maintenance of a car at any point in its travel. The mistake should not be made, either, of supposing that this system of car interchange benefits chiefly the railway companies. While they reap the first benefit, by far the greatest advantage results to the public, which has its traffic moved long distances at rates far lower than would be possible without this system.

Of course all agree that the abandonment of existing standards is wholly unthinkable, and the metric system advocates therefore propose that we shall simply restate the old standards in metric dimensions. Now, while this is possible theoretically, it is not possible practically. You cannot compel people to call a spade an "agricultural implement," even by the most despotic system of government. How, then, will you compel the plumber who wants a piece of 1¼-in. pipe to ask for a piece of "44.45-millimeter pipe." The thing is simply impossible. If we keep the old standards, people will continue to call them by their old names. You can no more change language by process of law than you can compel people by legislation to cease to speak of inches and feet and yards.

There is, therefore, no escape from the conclusion that the adoption of the metric system which is spoken of so glibly, is not in the direction of simplicity, but of confusion. It means not the displacement of present units of measurement, but the establishment of a dual system. As Mr. Halsey shows, France and Germany and the Spanish-American countries are still struggling with a multiplicity of units, compared with which our English standards represent the acme of simplicity and uniformity.

Of course if the metric system could be shown to be a great agent of social or economic good, if its adoption promised to be a panacea for many ills or to work vast and momentous reforms, then it might be worth while to subject the people and the nation to great inconvenience and disaster in order to secure it. But no such claims for the metric system have ever been established. Analyze all the arguments in favor of the metric system ever made and they will be found to consist for the most part of glittering generalities, or else of downright fallacies. It possesses some unquestioned advantages for the chemist, the physicist and the electrical engineer; and these already use the system to a large extent. It does not at all follow, however, that similar advantages will be found in its use in general trade and industry; in fact the bulk of the testimony is the other way.

We have deemed it proper to give up considerable space to this subject because the engineering profession has taken a prominent part in the agitation in favor of the metric system; and to a large extent, we are compelled to believe, without sufficient information. In the minds of many the metric system appears to be in some way identified with progress and the adoption of scientific methods. To favor its adoption appears to be esteemed a sort of shibboleth to testify that a man is educated and progressive and not an old fogy. There is even some excuse for this feeling, for some of the opposition to the metric system in the past, based on the alleged sacred origin of the inch or yard has been wholly absurd. Naturally men of intelligence have preferred not to rank themselves with those who have attempted to trace the inch to a connection with the Pyramids, or who have objected to the metric system because it was originated by atheists.

A deal of misapplied energy has been expended, too, in trying to prove the innate superiority of one system to the other. The real fact is that with either system it is entirely possible to conduct business without difficulty. The decimal system has certain advantages, and the English system, with its convenient vulgar fractions has certain other advantages. With either system these advantages can be retained. In the English system, for example, the 100-ft. surveyor's chain, and the 1-1,000-in. micrometer in the machine shop are here to stay. So with the metric system, vulgar fractions are bound to be used, simply because the ordinary mind grasps them much more easily than decimals. If cloth is ever sold here by the meter at retail, it will be halves and quarters that will be asked for by the customer and never tenths. People can use successfully, then, either the metric system or the English system; and the real matter on which attention should be concentrated is the difficulty of changing from one to the other. This difficulty, moreover, is not as is commonly supposed, the mere cost of equipping workshops and factories with new sets of gages and measuring instruments and standards. That would be an enormous amount, but it is far from being the chief item. The real source of enormous difficulty and expense is the millions upon millions of transactions of daily life which will be rendered more difficult and costly by the continued use of two standards during all the fifty to a hundred years or even longer that would be required to make the change from one standard to the other.

Finally, as we said a year ago, in such a country as ours, legislation to compel a change in existing standards will be an impossibility. Congress may, if it chooses, pass the pending law and create a vast amount of difficulty and expense in connection with government business; but no political party will ever dare to compel the use of the metric system in ordinary transactions. Without actual compulsion, however, no change will ever be made by people in general in the standards of weights and measures with which they have always been familiar. That means that the inch and pound and gallon are to continue in use; and thus the chief argument for the metric system—the establishment of a single international standard—falls to the ground.

LETTERS TO THE EDITOR.

Standard Crowns for Street Pavements at Omaha, Neb.—Correction.

Sir: In your issue of Nov. 20, containing a table of standards of crowns for street pavements, through inadvertence of mine, the classification includes macadam which would be only applicable on very heavy traffic roads, and should not be included for use in that table.

Very respectfully,

Andrew Rosewater, City Engineer.

Omaha, Neb., Nov. 24, 1902.

Temperature Stresses in Aluminum Transmission Wires.

Sir: Some time since, I sent you a certain formula for computing temperature strains in strung wires, which formula you were good enough to publish (Engineering News, Nov. 6, 1902, p. 382), making, however, at the same time a very sarcastic criticism. Under ordinary circumstances, I should be inclined to accept any such criticism in the kindest spirit, and profit by the experience thus gained; but when, as in the present instance, the substitute offered for my method seems to make it appear that I have been abstractedly chasing a phantom, and have arrived at an abstruse theoretical result, having no practical value, and which may be replaced by a foolishly simple method, I think you will agree with me, after a little consideration, that I am justified in asking you to reprint the formula and modify the statements which you have made, especially as the formulas that you have offered lead to absurdities.

If you will take the trouble to figure out an assumed case, say, an aluminum wire strung on a span of 100 ft.,

with a sag of 1.57 ins. at a strain of 11,000 lbs. per sq. in., you will find, according to the formulas offered by you, that a rise of 100° F. would increase the sag to 26½ ins., at the same time lowering the strain to 650 lbs. per sq. in. Now, as a matter of fact, it would take more nearly 200° rise of temperature to produce this sag; the real increase would be only about a foot. The reason for the error is apparent after a little thought: it is due to the neglect to take any account of the contraction of the wire by virtue of its elasticity, which contraction tends to shorten the wire as the strain is relieved; that is, as the temperature is increased, and therefore works against the temperature effect, and lessens it by an amount which is far from negligible.

Now, as to the matter of "d" occurring in the third power, which you make a point of, it so happens that the original maker of aluminum wire, temperature and things mystified our feeble minds to the extent of involving this deflection in a cubic equation. He equipped us, however, with the knowledge of how to solve it directly if necessary, and further enlightened us by instilling the conviction that life is too short to go to the trouble, when very much simpler trial methods are available. Yours very truly,

R. D. Johnson.

744 Ellicott Square, Buffalo, N. Y., Dec. 6, 1902.

The New York Canal Improvement.

Sir: The waterway problem in New York now demands final solution and more thorough consideration and broader treatment than it has yet received. The champion of the 1,000-ton barge canal admits it is a radical project, equivalent to abandonment of our present state canals and a start *de novo*. If so, no proper consideration can neglect the fact that we have provided deep water to Tonawanda and Troy, the starting points, by national effort; and that deep waterways of at least 21 ft. have been recommended by the United States Commission, after spending seven years and over $500,000 in securing surveys and complete data, making their report more comprehensively authoritative than the surveys made by New York state officials.

The Oswego-Mohawk route is common to both the state and national projects. Both the deep waterway and the bargeway would use Oneida Lake and for both we canalize the Oswego and Oneida Rivers and the Mohawk—by reason of flood disposal much the same work is involved for either, and we have now a State Flood Commission to co-operate. The difference is therefore largely in the canal sections, mainly in the two divides between Oneida Lake and the rivers, 13 miles on the west and about 50 miles on the east. For the state to build only a bargeway here would be as ill-matured a scheme as was the $9,000,000 improvement and will necessitate future abandonment of this $50,000,000 investment. How much better to provide now a 21-ft. waterway at least in river sections, only 9 ft. deeper than the 12-ft. channel, at less than double the cost.

If the state were to bear the whole cost, it could be readily paid for by making the bonds run 100 years instead of 50 years, as is now proposed, and national co-operation would reduce the state's share below that of its present undertaking.

Should the state and the United States co-operate in building a canal on the Oswego-Mohawk route, the state would be better able to build an interior bargeway from Buffalo to Oneida, and the United States could build an adequate deep waterway around Niagara and do the work necessary to secure 21 ft. depth in the Hudson.

The proposed 12-ft. bargeway will still compel transfer at Buffalo—still leaves the advantage of superior facilities to the upper lakes in transportation and industries—still localizes their shipyards and, keeps cooped above Niagara their output, and 500 of the 800 vessels of over 1,000 tons already built.

The deep waterway provides for Ontario and the other lakes and rivers in New York facilities equal to those now enjoyed above Niagara and predicates for our state a like development in iron and steel and shipbuilding, which the bargeway cannot. It provides an adequate waterway between the lakes and the seaboard. It will be a thoroughfare for all American vessels. It will give New York supremacy as a seaport and satisfy the expectations of the nation, and bring through it the business of all Canada.

John A. Collier Wright.

Rochester, N. Y., Dec. 8, 1902.

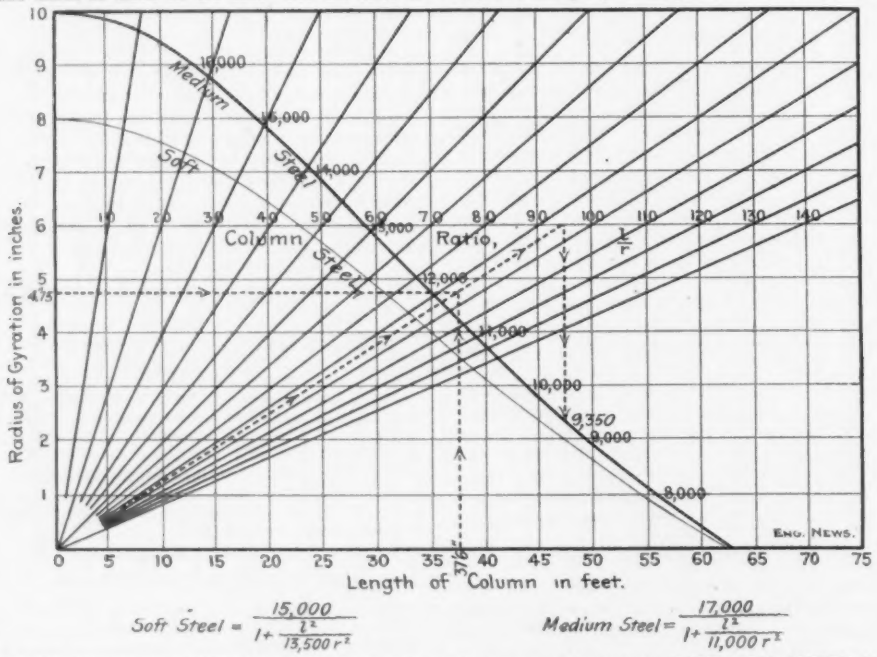
Diagram for Unit Stresses in Steel Columns.

Sir: I enclose you copy of a diagram for finding the unit stress values for columns when the length (in feet) and the radius of gyration (in inches) are known. The example worked out by the dotted lines on the diagram assumes a length of 37 ft. 6 ins. and a radius of gyration of 4.75 ins., and gives a value of 9,350 lbs. per sq. in. for medium steel. I personally have found that this table saves a good deal of time in designing. If you think it would be of any use to others you are at liberty to publish it. I would like, though, to apologize in advance to the inevitable person who did the same thing twenty years ago.

Very truly yours,

H. M. Knapp.

440 Seville St., Philadelphia, Pa., Nov. 27, 1902.



$$\text{Soft Steel} = \frac{15{,}000}{1 + \frac{l^2}{13{,}500\,r^2}} \qquad \text{Medium Steel} = \frac{17{,}000}{1 + \frac{l^2}{11{,}000\,r^2}}$$

DIAGRAM GIVING ALLOWABLE UNIT STRESSES IN STEEL COLUMNS, BASED ON AMERICAN BRIDGE CO.'S COLUMN FORMULAS.

Example: Length of column..... = 37.5 ft. } Medium steel column; then from diagram, allowable unit stress
Radius of gyration..... = 4.75 " } is 9,350 lbs. per sq. in.

The Cost of Mine Timbering.—A Criticism.

Sir: In your issue of Nov. 6, 1902, is an abstract of a paper on the cost of square set timbering by Mr. Bernard MacDonald which is of interest to me, as I have been doing some figuring along that line during the past week.

I would like to call in question the accuracy of Mr. MacDonald's figures on the cost per ton. If he had stopped long enough to draw a diagram of a stope timbered by the square set method, he would have discovered that in no case will one post, one cap and one girt make a complete set; and therefore his figures on the cost of the timber per ton of ore mined are incorrect.

For instance, a square stope with 10 posts on each side will have 100 posts on each floor and only 81 sets. This same stope would have 90 caps and 90 girts on each floor.

Another case is of a long narrow stope, say two sets wide, and ten sets long. This stope would have 33 posts, 22 caps and 30 girts, but only 20 sets. If the outline of the stope is very irregular and the stope narrow, the proportion of posts, caps, and girts, in relation to the number of sets, will be still greater.

I think Mr. McDonald must have taken the word of the shift-boss for his statement that one post, one cap and one girt constitute a set. Very truly,

B. C. Yates,
Assistant Engineer Homestake Mining Co.

Lead, S. Dak., Nov. 10, 1902.

[In accordance with our custom, we submitted the foregoing criticism to Mr. MacDonald, whose reply follows.—Ed.]

Sir: I have to thank you for the proof sent me of Mr. Yates' criticism on my paper, "Mine Timbering by the Square Set System at Rossland, B. C." It is not the pleasure to have Mr. Yates' acquaintance, but I would judge from his criticism that he is a comparatively young man, and was very likely struggling with the multiplication table at a time when I was on a "timber gang" erecting "square sets" in mines with my own hands. It is just about a quarter of a century since I began to wrestle with the practical end of the square set system of timbering in mines, and at intervals since it has been my duty to study this system from both scientific and economic standpoints. Hence if I am now obliged, as Mr. Yates suggests, to go to the shift boss for information as to how many members constitute a square set, I must have failed to have taken advantage of my opportunities.

But I know the facts are correctly stated in my paper, and I know Mr. Yates would not have made the error and accusation contained in his criticism if he had read my paper carefully and had studied the problem. In my paper, under the head of "Per Tonnage Cost of Square Set Timbering," I have said:

After the sill floor is laid and the framework started, a square set, which is made up of one post, one cap and one brace, consumes 18 ft. 6 ins. running feet of logs.

Now, it is true, under the conditions stated, that one post, one cap and one brace (three pieces in all) constitute the entire members of a square set whether the exhausted vein to be timbered was 10 ft. or 100 ft. in width. If Mr. Yates will take a simple case, say, where the vein dips exactly 45°, and make a diagram showing a vertical cross-section of the square sets in place, he will see the truth of my statements. Sincerely yours,

Bernard MacDonald.

Spokane, Wash., Dec. 1, 1901.

The Viewpoints of the Outdoor Man and the Indoor Man.

Sir: The writer has been an employer of men numbering in the thousands and he is naturally interested in sociological data. In reading the report of Industrial Statistics for 1901, published under the supervision of the Secretary of State of Pennsylvania for Internal Affairs, he was impressed with the labor it involved and also with the impossibility of presenting facts in their entirety by statistics only. This is no reflection on the report, which is colorless and impartial, as it should be. It is simply qualifying the influence of Quetelet. Mr. Quetelet, in being the parent of statistics in a certain sense, did us much good and assisted in changing our descriptives from superlatives into units of graduation or measurement—but it is fascinating to the nimble witted, sitting in a comfortable office, to juggle with figures. It is easier than going out and looking at the facts, and so the statistical tendency is indulged and the athletic tendency submerged, and the nimble-witted have done the outdoor man much injustice. These influences are appreciated by able executives and they choose men with special qualifications for inside and for outside work, and the outside man in well-managed establishments and certain work is apt to carry more weight. This statement is made chiefly as regards "management," which is a more variable science than the science of engineering.

I put down the results which I gathered from this book of statistics and felt the truth of that "mot," "Figures don't lie, but liars will figure." If the grouper of statistics is thinking of the appetite of the adding machine rather than the relations which the public are anxious to prove or disprove, his figures will be wrongfully interpreted. For in all statistics there must be rejection and qualification. What I gathered from these 650 pages of statistics, disregarding literary matter, are the following relations concerning earnings and wages:

1. Wages go down in plants poorly located.
2. Wages are highest where the value of the output per man is highest.
3. Wages are highest where dangers are incurred or where the work requires a good body and a good nerve.
4. The size or weight of finished product seems to have something to do with the earnings.
5. Wages vary more in iron products than in other industries, such as slate, brick, glass, paper, etc.; the variations in iron earnings are more abrupt.

The writer, while acknowledging his debt to the auditor and accountant, cannot accept their postulates only and he ventures to qualify them as follows:

1. This is obvious. Plants located far from the raw material, far from the market, or in an overstocked labor community cannot pay the same wages as plants better located. Wilkesbarre and Scranton average $446 yearly earnings against $560 for Johnstown and Altoona. I have selected these cities because their industries are closely

allied. I could have said Norristown with $340 against New Castle's $646, but other facts known to the writer and not presented in the columns influence this. These figures are from the Federal Census of 1900.

2. Wages are higher where the value of final output per man is highest; that is, generally speaking:

Industry.	Value of output per man.	Men's yearly earnings, 1901.
Rolling-mill products	$5,085.39	$692.10
Pig iron	5,549.30	576.72
Nuts and bolts	2,139.19	406.38
Pianos and organs	1,234.96	437.73
Hosiery	882.27	273.62

The above seems quite conclusive, but may not the iron mills be enabled to make a large output through improved machinery, so complex as to require a high grade expensive man to run it? The law of supply and demand is, as all know, the first and paramount influence.

3. Wages are influenced by danger incurred and strength required. This is closely related to statements (2) and (4). It is not everyone who is robust enough to follow the iron business, particularly the pig iron or blooming mill or converter end, or the devil-may-care job of riveters and riggers on elevated structures. Their earnings are more than those of the men who feed the bolt machines or even than one who adjusts the tool in a drill press. Nevertheless, the blast-furnace man does not earn anything like as much as the converter and blooming-mill men—one reason being their lower intelligence as a class—but the main reason is the fact that they are not organized. Furnace work, however, requires more strength, and is more dangerous or as much so as either of the other two branches of the iron industry.

4. The size and weight of the finished product seem to influence the earnings. However, as the book leaves out railroads, mining and quarrying, this cannot be closely followed; $623 for the earnings of an iron forger and $241 for yearly earnings of a worker on silk broad goods. Both in this and the bolt works it is boys and women who cut the wage rate; but the weight of the commodity, with the roof over head and the comfortable quarters, are reasons why women are employed. Another reason is because men in those sections receive low wages. The old plan of placing a textile factory in an iron town is apt to mean low wages for the iron workers.

5. Iron being a business barometer—the most sensitive of all trades—its periods of strength and depression are most marked and frequent. The earnings of the men vary more than in industries supplying wants required continuously and materials easily destroyed. Iron wages increased from 50 to 60% from 1894 to 1901, while hosiery wages decreased 3.2%. Iron being essentially associated with new buildings, new railroads and new enterprises, iron workers are idle except when hope and prosperity encourage the builder.

Now, I have shown practical qualifications applying to every inference, drawn from the above statistics, and I might have gone on and shown that wages are highest where they constitute the smallest element in the cost.

It is refreshing to turn from the 650 pages of columns and figures to the 50 pages comprising letters from employers. These letters, sent in answer to requests, were not signed. They express all sorts of theories and practices as to the best methods of settling and avoiding labor troubles. One feels somewhat as though in the midst of a Donnybrook Fair, or like repeating the unanswered inquiry as to who struck Billy Patterson. But these random shots of the outside man—for so we may regard these letters based on personal relations with the men—while exhibiting the lost motion usually attributed to the loosely geared outdoor man—hit facts missed by the more favored executive. A few ideas which follow are suggestive.

One man favors unions and uses the union tag on the article he turns out. Possibly where the chief cost of a commodity is in the raw material and the labor is a small item it might pay to take this stand rather than take the loss incident to a fight. Then in small affairs, a local market may demand the "Union tag."

Another man thinks personal intercourse with the men a great safeguard against strikes and thinks (correctly) that they are less liable to occur where there are not many bosses and in plants employing less than 100 men.

Another believes in economizing by paying higher wages and working a smaller number of men at greater speed. This method may be called the Pittsburg or Carnegie principle. With an ambitious people in an invigorating climate it is the best; it is excellent for large corporations.

Some believe in heart-to-heart talks—this might go in a country village where life is not strenuous.

Some believe in a sliding scale based on selling prices; this certainly is a good idea.

One writer describes a system where the men are treated as the Captain in "Pinafore" treats his crew. But paternalism smacks of charity and the best man wants to wrest his living from the world. Employees tire of baths, lectures and libraries. They would be better satisfied if the money spent on such institutions were distributed in wages. The working man feels a suspicion that such methods are but the promptings of the creed of Becky Sharpe, who said, where a smile will do the work of two shillings—give the smile. This is frequently an unjust suspicion, and paternalism, while not equal to the Pittsburg plant in producing results, has some virtues, especially for those not possessing the highest degree of proficiency.

It is better than sweat-shop systems and is as yet so young in application that one cannot definitely say it may not be permanently a better theory than the Pittsburg theory. It is more frequently tried with new industries which are not liable to competition.

One letter is refreshing except that it makes the average manager feel how few such real leaders there are. It is from a tanner, who has risen by his own efforts and has not felt himself socially removed from his workmen. He spends his leisure hours in their society and writes that he knows what a man can do and don't ask them to do more than a man's work. Once they demurred because he thought a man's work should be 60 rather than 40 fleshings of hide daily, whereupon our proprietor strips his coat and fleshes 120. After this 60 was easily obtained from his men.

The esoteric man is necessary as well as the exoteric, but the manager must be familiar with both. A subject so vast as this cannot be easily treated, certainly not in a short article; but the rapid trend of events seems to demand an occasional "glance on both sides of the shield"—it helps to keep affairs properly balanced.

G. L. F.

Baltimore, Md., Dec. 1, 1902.

RECENT BRITISH PRACTICE IN REFUSE DISPOSAL FURNACES.

An interesting paper on refuse disposal and destructors (or garbage furnaces) was read before the recent meeting of the Royal Institute of Public Health, at Exeter, England, by Mr. F. Leslie Watson, Assoc. M. Inst. C. E., of Leeds. The prime essentials of refuse destruction are high temperature, complete combustion of solids, exposure of all the gases to the highest possible temperature before they escape from the furnace, and the prevention of the escape of dust to the chimney. Secondary to the foregoing, but of great importance, are economy of operation, "principally in relation to the labor bill, but also in relation to cost of maintenance and repairs;" utilization of both heat and clinker; and reasonable first cost. It is particularly significant to American readers, we may add, that no mention is made of keeping down the fuel bill, but that instead stress is laid on utilizing the heat generated by the burning waste.

Simplicity is an important factor in furnace design, particularly for the interior parts, the conditions affecting which "are all against the success of mechanical arrangements situated within the furnace." The author cites as an illustration "a large and costly destructor plant, which was a total failure simply through the introduction of a hopper feed and a moving grate bar, which have both worked well in coal-fired boilers for many years." Electrical hoists and other apparatus should be cased so as to exclude the "fine gritty dust in the atmosphere, which is an unavoidable factor in the working of destructors."

The absurdity of the short evaporative tests frequently made to determine the extent to which refuse may be utilized for heat production is pointed out by Mr. Watson. If he could pick his men, Mr. Watson states, "he would undertake to obtain on a six hours' run almost any result which may be asked for." The tendency to rely on "high figures taken on a six hours' run," deplored by the author, may explain some of the wild claims for heat utilization in Great Britain which reach America from time to time. "A safe figure," the author states, is "an evaporation of 1 lb. of steam per pound of refuse;" and he adds that:

> The power thus obtained is being utilized in this country for very varied purposes. Among these are municipal lighting, pumping of sewage, heating of public baths and wash-houses, driving of tramways, manufacture of mortar and concrete flags, and grinding and sifting material for concrete and plastering.

Water-tube boilers for refuse destructor installations are preferable because they lend themselves "much more readily to building into a brick flue for gas-firing purposes than any other type;" because they raise steam much more rapidly; and because it is easy to place a supplemental coal-fired furnace in a water-tube boiler and very difficult to provide it in a Lancashire boiler."

For the removal of clinker from furnaces a bucket is sometimes used, so mounted on an overhead trolley that it may be run up under and temporarily fastened to the deadplate. The bucket holds all the clinkers removed from one fire, and, the trolley wheels being provided with roller bearings, the clinkers are easily removed to the place of deposit.

The clinkers so removed are, at some works, crushed in a mill consisting "of a pair of fluted rollers cast with a chilled face, geared together and driven by strong double helical spur wheels, the rollers having a special elastic attachment to their spindles to prevent undue shock." From the crusher a chain belt elevator takes the material to a revolving screen. In case the clinker is to be used for making mortar, grinding mills weighing half as much again as the ordinary builders' mortar mill should be used, owing to the extreme hardness of the clinker.

For the manufacture of flagstones from clinkers the latter may be ground fine in a mortar mill, then mixed with cement and water and finally molded with the aid of a hydraulic press. To prevent warping and twisting the flags may be stacked in racks while drying. The drying process may be shortened from weeks to 48 hours by using a steam drying chamber. At Zurich, Switzerland, furnace clinker, with lime, has been made into a good quality of brick.

The combined refuse destructor and electric lighting plant at Fulham, England, includes a 12-cell destructor, six water-tube boilers mounted, one each between a pair of cells, two fuel economizers, and a dust-catcher. The gases from any pair of cells may be sent to any one of the boilers, or coal may be used to raise steam in any boiler. Mechanical stokers and forced draft are employed. Steam from the boilers is piped to the electric station, adjoining.

At Accrington, two cells and two 30 × 8-ft. Lancashire boilers, provided with a fuel economizer, produce a steam pressure of 200 lbs. One of the boilers "is fired with destructor gases, while the other may, if required, be coal-fired." The whole of the electric lighting plant has "been run for considerable periods without the use of other fuel than refuse." At Salisbury the heat from two refuse destructors is used to pump sewage.

THE USE OF A SURVEYING INSTRUMENT IN MACHINE SHOP PRACTICE.*

By Charles C. Tyler,† M. Am. Soc. M. E.

Many machine shops now have floor surface plates upon which large work is laid out and various machining operations are performed by the use of portable machine tools secured to the plate. The quality of the work produced is largely determined by the accuracy of the laying out, the correctness of the portable tools, and the trueness of the surface plate.

For work having moderate dimensions, scales, squares, beam-compasses, and straight-edges can be purchased in the market sufficiently accurate, if used by careful workmen, to meet the average requirements in laying out the work and setting the portable tools; but for work having large dimensions the scales, squares, beam-compasses, and straight-edges become quite special, are expensive, and require the utmost care in their manipulation to insure correct work. Ten-ft. steel squares and beam-compasses spanning 25 ft. are not easy tools to make or handle, and the fear that errors might be made in some large work, to be undertaken at East Pittsburg, led the writer to the consideration of doing away with these abnormal tools and substituting others more easy to manipulate and of a kind to insure accurate results.

The method decided upon has proved so reliable and satisfactory for nearly two years that a description of it may contain some suggestions of benefit to those using surface floor plates and portable tools. To carry out the method referred to we shall require a dividing and leveling instrument of somewhat special construction; for mounting the dividing instrument, a center column (with a taper hole whose axis is exactly perpendicular to the base of the column), a center gage, a straight-edge, several specially ruled targets, a surface gage, and other small tools.

Let us assume that we have a surface floor plate, suitable portable vertical slotters or planers, and portable horizontal drilling and milling machines, and that we are to construct a cast-iron ring of over 20 ft. outside diameter, properly proportioned. This ring is to be made of six similar sections suitably cored and ribbed, and the only operations to be described are the accurate planing of the joints, cutting the keyways, and drilling the holes for the clamping bolts.

Mount one section upon planed cast-iron blocks about 2 ft. thick and fasten securely to the floor plate, being careful to equalize any warped surfaces found in the casting. The center column is to be moved about upon the floor

*From a paper presented at the New York meeting of the American Society of Mechanical Engineers.

†Supt. Westinghouse Elec. & Mfg. Co., Pittsburg, Pa.

plate until its exact position in relation to the section has been determined by the use of the centering gage, and the column is then to be securely fastened to the floor plate, where it should remain until all the operations upon the section have been completed. (See Fig. 1.)

Mount the dividing instrument upon the center column, and with the telescope determine the correct position for the zero division of the divided circle, to insure equalizing the cut at each joint surface, and clamp the circle in this position. The next move is to secure a straight-edge or parallel to the floor plate in such a position that its front edge is in exact alinement with what is to be one finished joint surface. The location of the straight-edge is determined by the dividing instrument and by the use of a special target which rests upon the top of the straight-edge and has a zero line exactly in alinement with a shoulder which touches the front of the straight-edge. (See Fig. 2.) Another straight-edge is then to be secured to the floor plate under the other joint of the section, and its front edge must be set at exactly 60° from the first straight-edge; its position being determined by the dividing instrument and the special target used in the previous case. The accuracy of the location of both straight-edges being demonstrated by proof surveys, we are ready for planing the joint surfaces.

PLANING THE JOINT SURFACES.—For the joint planing operation let us use a portable vertical slotter or planer having the front edge of its base exactly parallel with the horizontal travel of the tool slide. Secure the portable slotter upon the floor plate with the front edge of its base exactly parallel to the front edge of the straight-edge; the accuracy of the setting being easily determined by a pin gage, and the fine adjustment being obtained by screw jacks bearing against the base and stop lugs inserted in the floor plate. While the roughing cuts are being made upon one joint surface, set a second portable slotter by the other straight-edge in the same manner and proceed with the roughing cuts at this end. In order that the workman while roughing may not cut beyond what should be the finished joint surface, it is advisable to scratch a finish line on the rim section at each joint, but the setting of the tool for its finishing cut is more easily and accurately made by the use of the telescope of the dividing instrument than by any other plan yet tried.

Before setting the tool for the final finishing cut it may be thought advisable to prove the surface of the last cut—a much simpler matter than at first appears. Let us suppost the last cut has left 2-100-in. stock to be removed and that we have a target with a center line adjustable in a line parallel with one edge. By resting the edge of the target against the surface and adjusting its center line until it exactly cuts the center of the cross lines of the telescope when set at the correct angle, we can survey the joint surface and prove that it is or is not parallel with what is to be the finished joint surface. If the surface be found correct, the finishing cut can be made at once; if there be an error, proper adjustment of the portable slotter must be made and the joint surface again surveyed after taking a light cut. The accuracy of the finished joint surface can easily be determined by the dividing instrument with suitable targets.

CUTTING THE KEYWAY.—If the keyway is to be cut parallel with the face of the rim section, the operation can be performed by a portable horizontal milling machine or a portable slotter having a horizontal movement to the tool slide—the correct setting of either machine to be governed by the straight-edge attached to the floor plate, and the exact vertical location of the keyway determined by a surface gage.

If the keyway is to be cut parallel with the axis of the rim section, the portable slotter can be used advantageously and the exact distance of the keyway from the center of the ring determined by a pin gage calibrating from the tool to a pin inserted in the taper hole of the center column.

DRILLING THE BOLT HOLES.—The axes of the bolt holes should be perpendicular to the joint surface, and they can easily be made so if the front edge of the portable horizontal drilling machine be perpendicular to the travel of the spindle and the base of the machine set parallel to the straight-edges attached to the floor plate. The exact position of each hole is better determined by a jig located by the keyway and a scratchel center line; but if the jig is thought too expensive, the holes can be quite easily laid out in the usual way.

For each of the other five sections the same process should be gone through, and it will be found much easier to adjust the center column and straight-edges than to attempt to locate each section.

TESTING PORTABLE MACHINE TOOLS.—By the aid of the dividing and leveling instrument it is easy to test the accuracy of portable machine tools. In the case of a portable vertical slotter the vertical travel of the tool slide can be determined by setting the instrument so that the cross lines of the telescope exactly cut a line drawn upon the tool block when at its lowest position. Elevate the tool slide to its highest point, tip the instrument, and note the position of the line on the tool block in relation to the cross line of he telescope. If the tool travel is in a line perpendicular to the base, and the instrument has been properly levelled, there will be no variation in the reading. If the tool travel is not perpendicular, the instrument indicates the error, and correction can be made in the portable tool itself or shims can be used under the base to correct the error. To test the parallelism of the transverse travel of the tool slide with the front edge of the base of the machine, set the front edge of the base parallel with a straight-edge secured to the floor plate in a surveyed position—one edge of the straight-edge being approximately perpendicular to the tool slide. Adjust the tool slide until it is exactly perpendicular to the straight-edge by the scratched line as determined by the telescope. A transverse movement of the tool slide to its near limit for position will indicate any error; if one be found, it is necessary to correct the machine by planing or scraping, as may be necessary.

To test the spindle travel of a portable horizontal boring machine, set the instrument to cut the line of a target attached to the end of the spindle, and survey the spindle in its different horizontal positions. The vertical travel of the spindle slide can be determined by locking the spindle in one position and moving the slide up and down the same as for testing the slotter. Other portable machines can be tested by similar means, and the results of the tests can be depended upon if the instrument is accurately made and the errors in the subdivisions of the circle are known.

PRACTICAL APPLICATION OF THE METHOD.

The method described has been practically applied to some of the mechanical operations incident to the manufacture of the eight 5,000-KW. alternating-current, engine-type, 3-phase generators built for the Manhattan Railway Co. by the Westinghouse Electric & Manufacturing Co.

The extreme height from the bottom of the bed to the top of the yoke is 42 ft., and the greatest horizontal distance over all is 44 ft. The bed plate, 43 ft. long, has two parts, securely keyed and bolted together, each 21 ft. 6 ins. long by 10 ft. 3 ins. wide by 2 ft. thick.

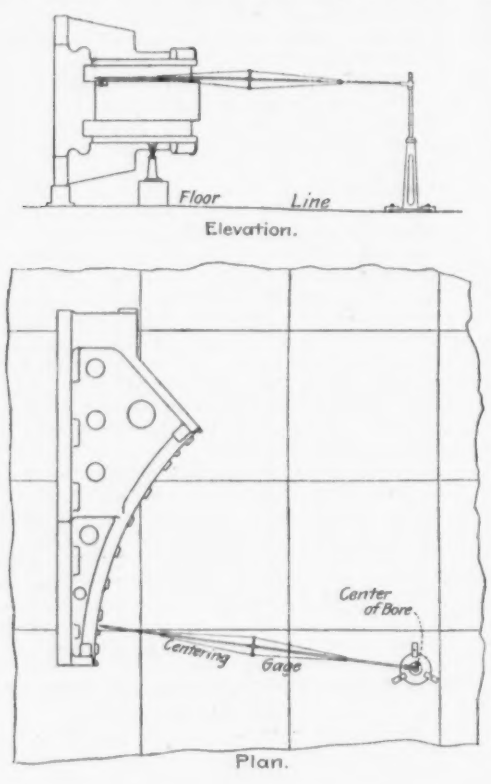
The stationary element, or armature, has six principal sections—two lower, two middle, and two upper—all securely keyed and bolted together, the bore being 34 ft., approximately.

The revolving element, or field, consists of many pieces, the principal ones being the cast-steel hub, the two web plates of six pieces each, and the four ring sections. The diameter of this element is 27 ft. 8 ins. over rim sections, and 32 ft. over all.

The total weight of the stationary and revolving elements of this machine (without the shaft) exceeds 1,000,000 lbs., or 500 tons.

After the preliminary design of these machines had been determined upon, it was apparent that the buildings, traveling cranes, and machine-tool equipment then in service at East Pittsburg were inadequate for the work. A new building was therefore erected, and electric traveling cranes were provided, having ample capacity and mounted on runaways of sufficient height to give the crane-bridge the necessary clearance over the top of the generators. It was also apparent, after carefully studying the design, that some of the machining operations could best be performed by the use of portable machine tools, while for others stationary machine tools would do the work more advantageously.

For the operations to be performed by portable tools, and for the erection of the machines, a surface floor plate was considered a necessity, and the one provided is 48 ft. wide by 176 ft. long; weight, about 2,000,000 lbs. This floor plate consists of 132 cast-iron sections, each 8 ft. square, of box section heavily ribbed, keyed, and bolted together—provision being made for the removal of any broken section, should such a mishap occur. The plate, well grouted, rests upon transverse brick piers 12 ft. deep built upon a solid bed of concrete, about 3 ft. 6 ins. thick. The brick piers are 4 ft. apart, c. to c., tied together at suitable distances by brick arches, and the space between the piers is filled in to within 5 ft. of the under side of the cast-iron plates. The filling between the piers is covered by a layer of concrete, having enough pitch to properly drain into a longitudinal tunnel at one side of the plate. There are numerous rows of drilled and reamed holes for stop lugs, and tee slots extend the whole length of the floor plate, with numerous cored holes at the



FIGS. 1, 2 AND 3. METHODS OF USING A TRANSIT INSTRUMENT IN THE CONSTRUCTION OF LARGE MACHINES.

bottom of the slots to permit the chips to fall through into the transverse tunnels. The longitudinal tunnel has numerous trap doors through which the chips can be taken out, and by a suitable sewer connection it is possible to thoroughly clean, wash, and drain this tunnel whenever necessary.

The principal portable machine tools used were vertical slotters or planers having a stroke of 8 ft., a small horizontal adjustment of the tool slide, a transverse tool travel of 4 ft.—the column having a horizontal adjustment of 4 ft.; horizontal drilling machines having a vertical adjustment of 8 ft., the column a horizontal adjustment of 4 ft., with spindle travel of 4 ft.; vertical slot-milling machines, radial drills and small vertical slotters.

The principal stationary machine tools were a 14-ft. planer, 8-ft. open-side planer, radial drills with 10-ft. arm, 16 to 24-ft. and 16 to 36-ft. extension vertical boring and turning mills, 28-ft. vertical boring and turning mill, 122-in. engine lathe, a special floor-boring machine carrying portable heads, and several smaller machines.

THE STATIONARY ELEMENT.

BED PLATES.—The bottom and top of bed plates were planed on the 14-ft. planer; the joint surface and keyway on the open-side planer, and the joint bolt holes were drilled on the floor plate with portable horizontal drilling machines.

BOTTOM SECTIONS.—The bottom sections were the most difficult to machine, and a more detailed description of some of the operations on these pieces will make it unnecessary to outline so fully the operations on the other sections.

The lower or perpendicular joint is at right angles to, and the upper joint has a portion parallel to, the bottom or base—the remainder of the upper joint being at a definite angle from the lower joint. The rough casting was mounted on the floor plate, resting on cast-iron blocks, the bottom being set approximately perpendicular to the plate, as shown in Fig. 2.

The proper location of the section involved the making of numerous measurements to insure plenty of stock for finishing—this being particularly necessary for the slot lugs located in the bore. The center column was mounted on the floor plate and its position determined by the centering gage, as shown in Fig. 1—more or less proof testing being necessary to insure its exact location, after which it was securely clamped to the plate.

The perpendicularity of the faces of the slot lugs was determined by scribing lines upon the top surface of the slot lugs with the center gage at the proper elevation, and by lowering the center gage rest or support, similar lines were scribed on the bottom surfaces of the slot lugs—scale measurements being accurate enough to prove this setting, after which the bottom section was bolted to the floor plate. The dividing instrument was then mounted upon the column, properly levelled, and finish lines scribed at each joint surface.

Straight-edges were then secured to the floor plate in their exact position—one edge of each being set exactly perpendicular to the desired finished joint surface, the position of these straight-edges being determined by the dividing instrument and suitable target, as shown in Figs. 2 and 3.

After proving the exact position of these straight-edges, the portable slotters were set in their correct location, secured to the plate, and the roughing cuts taken—slotters often working upon both joints at the same time. The accuracy of the rough planed joint surfaces was proved by the dividing instrument and an adjustable target, after which the cutting tool was set by the instrument for the final radial finishing cut. For that portion of the upper joint of this section parallel to the bottom, the slotter was set by the aid of an angle template—a pin gage proving that the tool slide was parallel with the angle template.

The joint bolt holes were drilled by portable drills, the position of the bolt holes being determined by the use of drill jigs located by keys and by a center line. The drill jigs were made reversible for drilling holes in the faces of the corresponding joint surfaces of the connection sections.

After completing the operations upon the joint surfaces, the lower sections were finished upon the bottom on a stationary planer, as shown. The next operation was the drilling of the bolt holes and the drilling and tapping of the adjusting screw holes in the bottom of the section under radial drills.

The operations upon the joint surfaces of the middle and upper sections were laid out and finished in substantially the same manner as were those on the lower section.

FIRST ASSEMBLING OF THE STATIONARY ELEMENT.—After finishing all the principal operations upon the joints of the six sections, the two lower sections were placed in position on the floor plate and the lower joint bolted together. The two middle sections were next placed in position and securely bolted to the lower sections. After assembling the two lower and two middle sections of the first generator, it was thought advisable to survey the surfaces of the upper joint of the middle sections to be sure that they were level and in exact alinement with the center of the machine. These surfaces were found to be so accurate that surveys of the same were not considered necessary on succeeding generators.

One of the upper sections was next placed in position and securely bolted to one of the middle sections. As the joints of the upper section were planed at an angle of 90°, and as the bore was 34 ft., the distance from the inner edge of the horizontal joint to the center was 17 ft. If there were not any deflection the vertical joint would have been exactly in alinement with the vertical joint of the lower section, but it was found that the upper joint over-hung 0.06-in. in the first generator, and the over-hang in the succeeding seven generators in no case exceeded 0.11-in. The total variation between the generators, therefore, was 0.05-in. The amount of over-hang was determined by the use of a plumb line—the elevation of the surveying instrument not being sufficient to permit its use.

The second upper section was next placed in position and first securely bolted to the middle section. After this was done an examination of the upper joint was made, and it was found that a very thin piece of sheet steel could be inserted at the lower edge of the joint, while it was tight at the upper edge. When the bolts were put in place and well tightened the joint was absolutely tight all over, and tests with the plumb line showed the joint to be exactly in alinement with the vertical joint of the lower sections. The variation in the alinement of the vertical joints of eight generators did not exceed 0.03-in.

Careful measurements of the vertical diameter were made before the second upper section was put in position, and in every case but two it was found, after placing the second upper section in position, that the tightening of the bolts of the upper vertical joint actually increased the vertical diameter by an appreciable amount, although not exceeding 0.05-in. in any instance. This result seemed to prove quite conclusively that no errors had been made in laying out the work or in planing the joint surfaces. It also proved to those responsible for the work that the method was practical, and that the dividing instrument could be relied upon for accurate results. After assembling the six sections and making proof measurements, the work of chipping the edges of the joints, broaching the sides of the keyways, and fitting the keys was performed, Careful measurements of the horizontal and vertical diameters were recorded, and then the frame was taken apart.

SECOND ASSEMBLING OF THE STATIONARY ELEMENT.—The six sections were next assembled on the special floor-boring machine—the axis of the bore being in a vertical position. This boring machine is 48 ft. square and has a rotating table over 18 ft. diameter, carrying various portable tool heads, which, for large work, are supported on arms having sufficient radial adjustment to bore up to 40 ft. diameter. The driving mechanism is entirely under the floor, with operating levers at the side of the machine. Current for driving the motors operating the feed mechanism of the portable tool heads is carried up through the center of the rotating table, where connection can be made by flexible cables.

The assembling of the six sections followed in the order of the first assembling. The lower sections were positioned by a heavy angle-plate securely fastened to the boring machine, which determined the exact distance from the center to the bottom of the generator. After the sections were properly blocked and bolted together, careful measurements were made of what were the vertical and horizontal diameters, when the sections were first assembled. In each case it was found that the former vertical diameter had increased 0.12-in. and that the horizontal diameter had not changed materially, showing that most of the deflection was in the upper section. By numerous heavy braces and taper wedges the upper sections were sprung toward the center until the diameter corresponded with the diameter recorded during the first assembling. The frames were then bored, faced, and recessed to the required dimensions. The dove-tailed slots for holding the sheet steel laminations were planed and milled—the spacing of these slots being determined by the table of the boring machine.

The table was graduated as follows: In the edge of the table there were 360 holes drilled ¼-in. diameter, into which were driven brass plugs. The edge of the table was slightly recessed and the brass plugs faced to protect them from injury. The dividing and leveling instrument was mounted upon a column accurately fitting into a recess in the center of the table, and a target was set up at quite a distance away. The subdivisions of the circle were obtained by rotating the table until the cross line of the telescope exactly cut the line on the target for each degree—the line then being made on the brass plug by a special graduating fixture attached to the bed of the machine.

After the operations were all performed on the frame the six sections were taken apart. The sheet-steel laminations, ventilating plates, end plates, and clamping bolts were next assembled with each section of the stationary element.

END PLATES FOR STATIONARY ELEMENT.—The end plates for clamping the sheet-steel laminations were made from steel castings and were 35 ft. 4 ins. outside diameter, with 16 ins. face. These plates were turned on a 36-ft. extension vertical mill. The end plates were carried on plates mounted upon 12 outriggers bolted to the 14-ft. table of the mill. To these outriggers were attached adjustable shoes resting on an annular bearing 29 ft. diameter, which gave sufficient support to the outriggers and relieved the table of undue strain. The driving mechanism for this mill was the same as in a 16 to 24-ft. extension mill and was not of sufficient strength to permit of taking heavy cuts.

A worm-gear drive was recently provided having somewhat unusual sizes. The cast-iron worm gear has 180 teeth made in 12 sections having 15 teeth each; pitch diameter, 33 ft. 5 ins.; face, 13½ ins. The 12 sections are securely bolted together and bolted to the outriggers. The worm is of cast iron, 20 ins. diameter, 20 ins. long, 7 ins. pitch, single thread of involute rack tooth form, 30° included angle. The worm is driven by suitable gearing and runs 30 to 63 revs. per min., driving the table one turn in 8¾, 6, 4, and 3 mins.; cutting speeds, at 36 ft. diameter, 13, 19, 28 and 37 ft. per min.

THE DIVIDING AND LEVELING INSTRUMENT.

The instrument in daily use at East Pittsburg was designed and made by the Warner & Swasey Co., of Cleveland, O., who kindly furnished the writer with the following description:

The knurled base on which the instrument rests is provided with an internal thread for screwing it to the cap of a tripod; or, if it is preferred, a supplementary base can be screwed to it, the latter being provided with a taper hole for readily centering the instrument on a suitably designed cast-iron column. The knurled base has four leveling screws, by which the body of the instrument is attached, the usual supporting ball and socket joint being provided in the center between the two.

In the center of the instrument are two vertical spindles, the one fitting inside the other. The outer spindle carries the horizontal circle independently from the inner spindle, which carries the supporting yoke and the telescope. The circle is provided with clamps and slow motions so that its zero division can be brought to any position in azimuth, and there clamped independently of the telescope. The circle is 12 ins. outside diameter, and is provided with an inlaid silver strip or band ¼-in. wide divided into 1-6°, which are read by vernier and reading microscope to 10″. The circle also has a second series of graduations, which are read by two opposite microscopes, with a magnifying power of 24, direct to 1-10°.

The yoke is mounted on the inner spindle and is provided with clamps and slow motions, so that the telescope can be moved to any azimuth position relative to the circle and independently of it. It has 2′ horizontal levels, 90° apart, for quickly setting the instrument. The telescope rests in a cradle so arranged that it can be revolved about its long or optical axis, the cradle resting in Y bearings which are reversible for collimation, the line of collimation being perfect from a distance of 10 ft. to infinity.

The telescope has an objective 1½ ins. in diameter, a focal length of 11 ins., and give, with two eye-pieces, magnification of 15 and 22, respectively. The eye-piece has the usual cross wires and focusing adjustment with rack and pinion.

The cradle trunnion carries a slow-motion arm, which can be clamped at any position for accurate altitude setting. The striding level is 7⅛ ins. long, has an air chamber and divided scale, 1-10-in. bubble travel being equivalent to 10″ of arc.

Mr. Swasey has stated to the writer that the greatest error in the subdivisions of the circle of this instrument would not exceed 1″ of arc—an amount equal to 0.3072-in. at a distance of one mile.

So many uses have been found for the instrument, and it has proved so valuable that a second one was recently ordered to be on hand in case of accidental injury to the one now in service.

GRADE REDUCTION ON THE MINNEAPOLIS & ST. LOUIS RY., AND THE NORTHERN PACIFIC RY.

The improvements now being carried out by the Minneapolis & St. Louis Ry. include some extensive changes and heavy work for the reduction of grades and curvature between Chaska and Hopkins, Minn. The following table gives a comparison of the physical characteristics of the present line with the revised line. It will be noticed that the summit is practically the same in both cases, but the new line reaches the summit by long and easy grades with few curves, while the old line has a broken profile with short steep grades and numerous curves. For the table given below we are indebted to Mr. H. E. Kelley, Chief Engineer of the Minneapolis & St. Louis Ry., Minneapolis, Minn.:

	Line	
	Present.	Revised.
Length of line	10.70 miles.	10.61 miles.
Ruling grade	1.25%	0.6%
Number of curves	23	6
Total degrees of curvature	553° 02′	173° 00′
Maximum degree of curvature	5°	1° 30′
Line on curve	37.04%	31.68%
Line on tangent	62.96%	68.32%
Line on level grade	6.01%	21.00%
Sum of ascents	268.0 ft.	187.5 ft.
Sum of descents	131.0 "	37.0 "
Maximum summit height	133.0 "	132.0 "

As in very many cases of grade reduction, the fact that improvements are now being made does not at all indicate a bad original location. In this particular case, the old location with 1%

grades and 5° curves was warranted by the traffic conditions and the motive power equipment. The new location will enable the loads of the mogul freight engines to be increased from 1,000 tons to 1,500 or 1,600 tons.

There will be some very heavy cuts on the new line, and several soft marshes or muskegs will be crossed by solid banks. As the banks are built their weight will break through the surface crust and the material will sink to the firm stratum below the mud, so that when the banks are completed they will have a solid foundation.

It may be interesting to note here, that on the Northern Pacific Ry., which has spent enormous sums of money in physical improvements to the line, no individual small work of this kind is now undertaken unless it forms part of the general scheme of improvement over a length of, say, 500 miles. In some of the earlier grade reductions, work was done which had to be done over again, through being included in subsequent larger improvements. At the present time, therefore, long stretches of line are taken up for consideration, and their possible improvement carefully studied. If found desirable, a complete scheme covering the entire length is submitted. If it is approved, the various parts of the work may be done as a whole or piecemeal, as may be found desirable, but they will all eventually form part of the complete scheme.

On this road, the improvements in grade and curve reduction have not only enabled the train loads to be increased, but have enabled the heavier trains to be got over the road quicker than the lighter trains used before the improvements were made. This is due partly to the fact that with a reduction in number of trains, the number of passing places is reduced in still greater proportion. This avoids the various delays incident

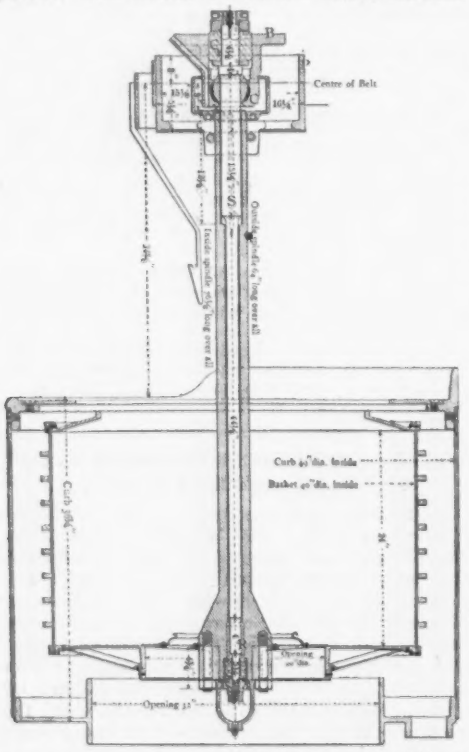


Fig. 1. Weston Type of Self-Balancing Centrifugal Machine.

to passing places, and the trains are thus able to get over the road in much less time than before, which in itself effects a material economy in operating expenses.

CENTRIFUGAL MACHINES AND THEIR USES.*

By Bartholomew Viola,† M. Am. Soc. M. E.

The author does not wish to consider the theoretical part of these machines, but to describe the main construction and the details as used at the present time. The familiar principle of centrifugal force of rotating masses is used for the purpose of separating juices, liquids, etc., from solids, and also to separate liquids of different specific gravities from each other, or to clarify dull liquids by separating from them the contained inert matter. When such mixtures are placed in a drum or kettle, and rotated rapidly, every particle will, of course, tend to move outward with a force expressed by the well-known formula $C = w^2 W r$, which indicates that the force is proportional to the squares of the angular velocity and the distance from the axis of rotation, and also to the weight of the respective substances. Consequently fluids will escape from the drum if there is opportunity and solids will remain.

The case of removing moisture from fabrics is very simple, as the material may be wound about an axis and fastened by a cord, so that while the moisture will fly off from the swift rotation, the web will be held. For the separation of uncompacted masses, such as rough sugar or chemical crystals, a drum-shaped vessel open at the top, and manufactured of the best steel, brass, or bronze, with holes in the cylindrical walls, is usually used, the axis of the drum being set vertical. When rotated the liquid will pass through the holes and flow down on the inner surface of an outside containing shell, whence it may be collected. For filtering impure liquids, the basket is lined with some porous material, which will allow the liquid to pass through but hold back the solid particles, but this method of filtering is little used, as the porous material soon clogs and has to be renewed.

Driving is usually accomplished by a belt or direct-coupled motor, and may be arranged either above or below the basket. In those where the driving mechanism is above the basket, there is always a possibility that oil may drop in and contaminate the material, but it is usually a more convenient form to arrange. A strong brake should always be provided for stopping quickly, and the basket should be strongly mounted and carefully balanced so that the center of gravity may always be in the axis of rotation. If this is not the case the vibration would soon destroy the whole machine, and the same result may be produced if materials are centrifugated, which will not form a homogeneous layer of even thickness on the inside of the basket. The speed of the machine generally depends on the size of the basket and on the material to be separated. A light basket can be run at a higher speed than a heavy one, and in general a basket 24 ins. in diameter, carrying a load of 170 lbs., can run safely at 1,500 revs. per min., while one 60 ins. in diameter, and with a load of 1,000 lbs., can only make 600 revs.

The typical construction for American and English machines is of the Western system, over and under-driven types being shown in Figs. 1 and 2. In both forms the principle of the revolving pendulum is used, the basket being allowed to oscillate within certain limits, thus balancing itself and reducing the power required to drive the machine to a minimum amount. In the European machines the axis is supported by a spherical bearing, so that the entire machine can accommodate itself like a spinning top, but is held from too violent motion by a collar bearing provided with a rubber buffer and tension rod.

The construction of the most important part of a self-balancing centrifugal machine, the Weston spindle, is shown in Fig. 1, B is a strong bracket or block, bolted to the overhead beam; C is a spherical bearing resting upon the block B, and in turn supporting the steel spindle S; on the upper end of the spindle is a rubber buffer, C_1, held in place lightly by a nut on the upper end; at the bottom is a special form of step-bearing, R, which carries the outside revolving spindle. The pulley P is fixed upon the outer spindle, and the lower part forms the brake block, while at the bottom of the outer spindle is a flange which carries the basket. The hollow portion of the outer spindle serves as an oil chamber, so that the bearing R runs in a bath of oil, which is drawn out when necessary by means of a plug at the bottom.

Fig. 2 illustrates the Weston spindle for an underdriven machine, and at the same time shows the arrangement when water power is used, as the driving is done by a Pelton wheel, G_2. The India-rubber buffers are used to allow the spindle to swing slightly, and thus conform its center of gravity to its center of rotation. These spindles require periodical adjustment and tightening, which has often been a laborious task, involving the dismantling of the machine in order to get at the nut which compresses the buffer on the top. With the new type of machine the nut is placed below the buffer at g, and is turned by a small pinion, i, which gears with a flange on the nut.

The method of driving which is most suitable depends upon the class of work for which the machine is to be used. For the manufacture of fine sugars and similar uses the basket may be fully charged at full speed, and will give a uniform fitness of material all around the basket; but if coarse or low-grade materials are to be handled, the speed must be gradually attained, three or four minutes being taken in reaching maximum velocity, because either the charge will not distribute itself evenly, or with low sugars, which are heavier than the molasses or liquors which it is desired to remove, the solid part of the charge will pack against the outside of the basket, and the liquids will have great difficulty in passing through. By coming to speed gradually the liquors will begin at once to leave the basket, and will thus keep the wall porous. For the former class of work, therefore, belt driving from a main shaft will answer admirably; but for the latter some form of individual motor, such as the water wheel of Fig. 2, the direct-coupled engine, or the belted engine should be used.

European machines are largely of the under-driven type, and the best were those of Albert Fesca or Fesca's principles. It is plain that a properly constructed centrifugal machine should be so balanced that there will be no pull on the axis or on the support in consequence of the rotation, and that the only side thrust will be due to the motive power. Even if a machine be balanced when empty, the center of gravity may leave the geometrical line of the axis when working with materials which do not distribute themselves evenly, and this will produce an unbalanced centrifugal force, causing vibration which increases with increase of speed, and may become so violent as to wreck the whole machine. For this reason the greatest care should be used in the handling of such machinery, as, even when made of the best material, it is liable to explode, and in any case the power required to drive it will be much increased. This driving power when at full speed is not great for a well-balanced machine, but is very considerable during the period of starting and during the period when a load is being run in; great care should be taken, therefore, never to overload a machine, and the basket when made of steel plate should have the edges welded throughout their length, never riveted. As a safeguard every machine is provided with a strong steel outer shell, but this is not a guarantee of immunity from danger in case of explosions, as the writer has seen such a shell straightened out like paper and the rivets sheared as with a knife. Too sudden application of the brake, as well as too sudden starting, may be the cause of an explosion.

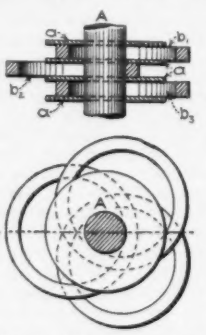


Fig. 3. The Fesca Centrifugal Machine Regulator.

Since an unequal load of as little as a pound of material is sufficient in a swift-running machine to cause vibration, it is important to avoid even slight amounts of unbalancing, and to do this Albert Fesca devised the ingenious regulator shown in Fig. 3 in detail. The balance rings run between washers a, and are free to swing in any position. Because of the friction between washers and rings, the rings will rotate with the shaft, but they will always shift to keep the center of gravity of the system in the axis of rotation. When the basket is exactly balanced the rings will stand at 120° with each other, as shown in Fig. 3, but if unbalancing occurs, the rings will swing towards the light side, the limit of effect being reached when all three are on the same side of the shaft.

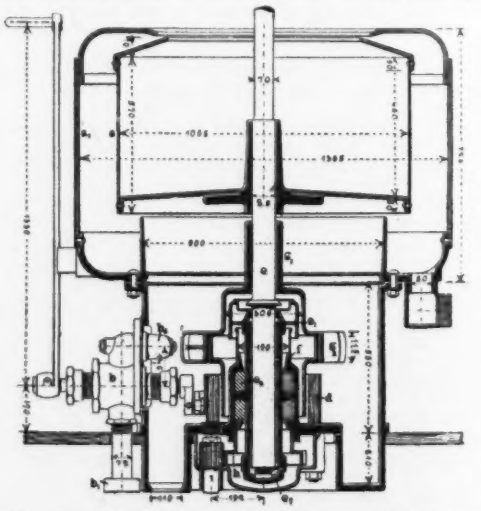


Fig. 2. The Weston Spindle for an Underdriven Centrifugal Machine.

Another device to accomplish the same purpose is shown in Fig. 4, which is a Hepworth machine of American manufacture. Here the lower bearing is so braced to the outer casing that the relative position of the two is fixed, but the casing is hung so that it may swing with the rotating part. As a matter of fact, however, practically no motion results, as the inertia of the casing is sufficient to take up any unbalancing. In this way very little strain is brought on the step-bearing, and the objection sometimes made that it consumes considerable power is not well founded.

The real disadvantage of this type of machine is that

*A paper read at the New York meeting of the American Society of Mechanical Engineers.

†Mechanical and Mining Engineer, Chemical Works of Chas. Pfizer & Co., 11 Bartlett St., Brooklyn, N. Y.

the bearings are inaccessible, but this has been overcome in later forms, as shown in Fig. 4. The center of the ball-shaped enlargement of the upper bearing, 531, is the fixed point about which the entire machine swings; the socket, 533, is bolted to the top of a beam shown in dotted lines, and the bearing extends through the beam and into the socket. The lower part of the socket forms the head, 534, which sunports by means of iron rods, 540, the lower part of the machine. The pressure on the ball-and-socket joint is regulated by the springs, 532. By study of the figure it will be seen that all parts of both the upper and lower bearings can be quickly removed by the loosening of a few nuts without taking apart the basket or the main shell. Both bearings are self-alining, the upper one by virtue of the ball-shaped enlargement and the sockets, and the lower one through being hung by link connections on three rods, 558. The brake, which is shown in detail at one side, is self-releasing, as in most other types of centrifugal machines, and self-adjusting. It consists of a band of steel, 542, with leather lining, and tightened by a bell-crank lever, 546. The discharge valve, 557, is a steel circle, which is lifted and placed on a hanger, 539, when the basket is to be emptied.

The difficulty with an under-driven centrifugal machine is to secure a suitable form of step-bearing, especially if the machine is made for heavy loads or high speeds, as in the manufacture of cube or loaf sugar. For this class of work the load runs as high as 4,000 to 6,000 lbs., and with the heavy basket and the heavy motor, since the motive power is usually a water-wheel or electric motor, the friction becomes very great. For such purposes the oil pressure step-bearing designed by Fesca is an important improvement. It is shown in detail in Fig. 5. The construction known as Adant's system is a combination of the rigid bearing with the buffer, uniting the advantages of both systems. In this step-bearing, the pivot Z of the vertical axis, slightly conical, fits the bearing L exactly, when the pin s rests on the plate P; when oil at sufficient pressure is forced through the pipe y the pivot Z is raised, the pressure needed being given by the equation:

$$\frac{\pi\ d^2}{4}\ p = G,$$

where d is the diameter of the pivot, G the weight of the basket and attachments, and p the pressure. The height by which the pivot is lifted can be determined by the angle of inclination of the conical pivot and the quantity of oil which is fed in continuously by the pipe y. Let h be the height through which the pivot is to be lifted, and α the angle of inclination of the pivot surface to the axis, then d_1, diameter at the height h, will be given by the equation:

$$d_1 = d + 2\,h\,\tan\,\alpha,$$

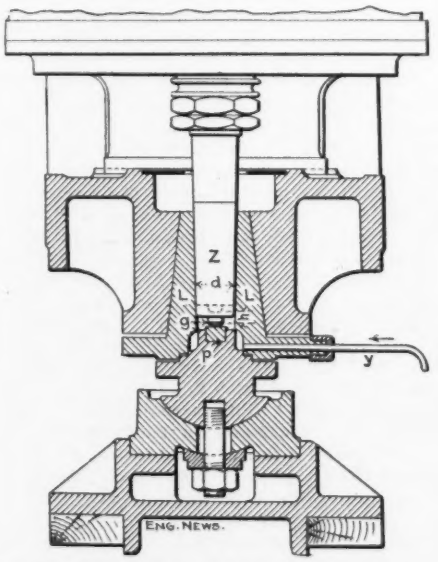


Fig. 5. The Fesca Centrifugal Machine Step-Bearing.

and the cross-section at this point for the passage of oil will be

$$A = \frac{\pi\ d_1^2 - d^2}{4} = \pi\ (d\,h\,\tan\,\alpha + h^2\,\tan^2\,\alpha).$$

In this equation the second term of the right-hand member may be neglected, and the expression will then become,

$$A = \pi\ d\,h\,\tan\,\alpha.$$

Through this section the quantity Q must pass in unit time with a velocity,

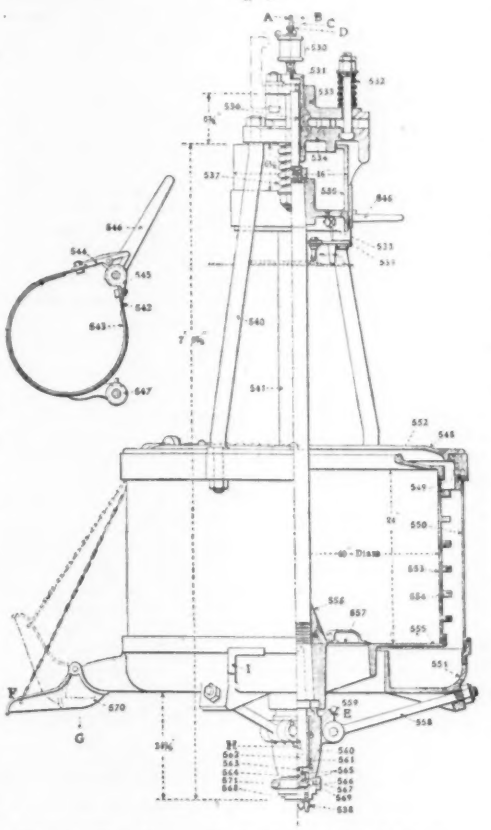
$$v = \frac{Q}{A} = \frac{Q}{\pi\ d\,h\,\tan\,\alpha}.$$

With the passing of the oil through the narrow annular opening, there will be a certain resistance per square inch proportional to the square of the velocity, which may be expressed:

$$w = K\,v^2 = K\,\frac{Q^2}{\pi^2\,d^2\,h^2\,\tan^2\,\alpha},$$

where K is a constant as obtained by experiment. But the resistance w is equal to the pressure p of the basket on the liquid,

$$p = \frac{4\,G}{\pi\ d^2},$$



bread in a frying pan or coffee in a tomato can, and in view of the general reverence for printed advice from those self-praised "experts," it was not to be wondered that "tenderfoot" prospectors started out equipped with everything under the sun, from toothpicks to cuspidores.

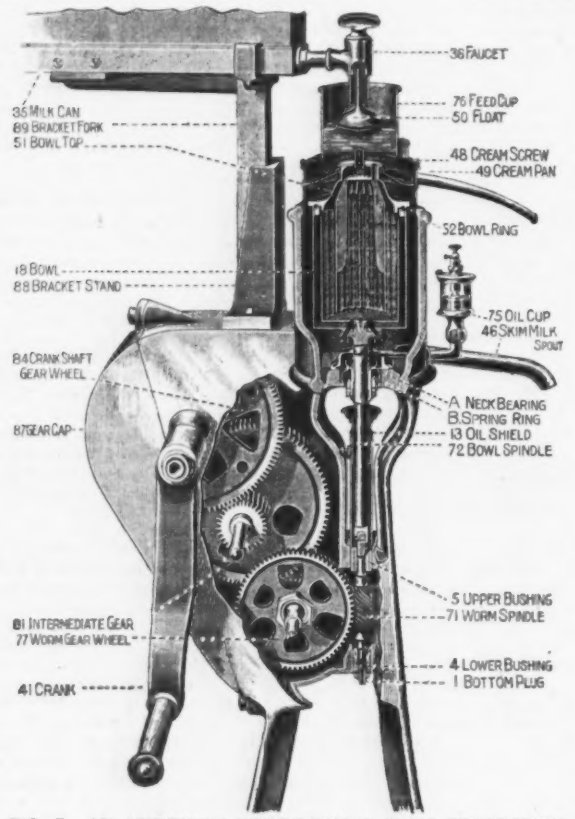


FIG. 7. AN AMERICAN CENTRIFUGAL MILK SEPARATOR.

All over this inventive land geniuses immediately began patenting the most remarkable devices in the way of wicker food baskets, which upon a moment's notice could be converted into steam launches or reindeer sleighs, as occasion might require. Patent hammocks were to be had which would serve as beds by night, and by day as nets to keep the flies away from—imaginary horses.

But not content merely with designing new camp equipment, inventors invented new foods. Dessicated eggs for the first time appeared upon the prospector's elaborate ménu, along with other similar evaporated foods, suited best to evaporated appetites.

"Among the things that might have been taught at college, but were not, what do you think would have been of most use to you immediately after graduation?" was the question once put to an engineer, who immediately replied: "A grub formula." It appeared that this engineer had been called upon to take charge of a surveying party, and among his duties was that of caterer for some ten men for several weeks, which is no easy task at best, but was made doubly difficult by the fact that frequent trips to the source of supplies were out of the question. Needless to say, the omniscient country grocer unloaded upon him all the stock for which he had found little or no sale. The engineer's collection of spiced preserves, canned turnips and the like would have done credit to a county fair. In camp mutiny was afterward prevented only by detailing a daily hunting squad to rustle for "green pemmican," or, as venison is called during the "close season" in some sections, "mountain veal." In reading over any provision list it should be remembered that what would lead to indignant protests at a city boarding-house if proffered only once a week—prunes, for example—may in camp become the "piece de resistance" three times a day, and be eagerly demanded at that. "There is no accounting for tastes"—especially in camp. Sweets, brown sugar syrup and the like seem to fill a long-felt want, and the amount of sugar consumed by campers is usually double that given in tables prepared by scientists.

Rations for One Man Prospecting 30 Days.

				Per man per day.
25 lbs.	flour	2¼ cts. a lb.	$0.56	0.83 lbs.
8 "	oatmeal	4 " " "	.32	0.27 "
4 "	rice	5 " " "	.20	0.14 "
8 "	dried beans	3 " " "	.24	0.27 "
12 "	sugar	6 " " "	.72	0.40 "
1 "	salt	1 " " "	.01	0.03 "
2 "	butter	25 " " "	.50	0.07 "
10 "	bacon	16 " " "	1.60	0.33 "
1 "	baking powder	40 " " "	.40	0.03 "
2 "	coffee	25 " " "	.50	0.07 "
¼ "	tea	60 " " "	.15	0.01 "
2 "	dried prunes	10 " " "	.20	0.07 "
¼ "	pepper	40 " " "	.10	0.10 "
3 cans	cond. milk	15 " a can	.45	0.10 "
78½ lbs.	Total		$5.95	2.72 lbs.

The accompanying list is based upon what was consumed by each man of a prospecting party in the Cascade Mountains, of which one of our editorial staff was a member. Everything had to be packed upon the backs of the prospectors, which accounts for lack of variety in the bill of fare and for its condensed form.

An occasional mess of trout was caught, but living would have been satisfactory without the fish, although they made a pleasant change. Coffee three times a day was demanded by every one of the party of four, with one exception, and he wanted tea at night.

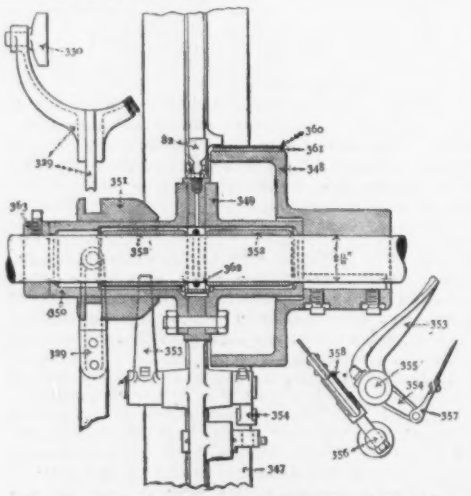


Fig. 9. Friction Drive of a Centrifugal Machine (Hepworth Pattern).

As for camp equipage, it was exceedingly simple, consisting of 6 pairs of blankets for 4 men, who doubled up; 4 strips of canvas, 4 × 7 ft.; one coffee pot (although a tin can could be made to serve); 4 tin cups and spoons, 2 frying pans, 2 gallon pots, one piece canvas to mix bread on, 2 prospector's picks, 1 shotgun and some fishing tackle, matches, soap and candles. Food enough for three weeks was carried, which, with camp utensils, blankets, etc., made each man's load about 70 lbs.—and that was enough! A well-seasoned man will carry 100 lbs. on his back.

Extra suits of underwear, and in fact anything at all extra will soon be dropped by the wayside or "cached." Harness or baskets for carrying or holding the pack are superfluous. In fact the very best thing for shoulder straps to support the pack is an extra pair of overalls, the two legs of which pass over the shoulders and fasten to the cords at the lower part of the pack, while the seat of the overalls is fastened to the upper part of the pack. Anything at all will soon make one's shoulders lame, but the overall legs, by presenting a broad surface, afford much relief from cutting.

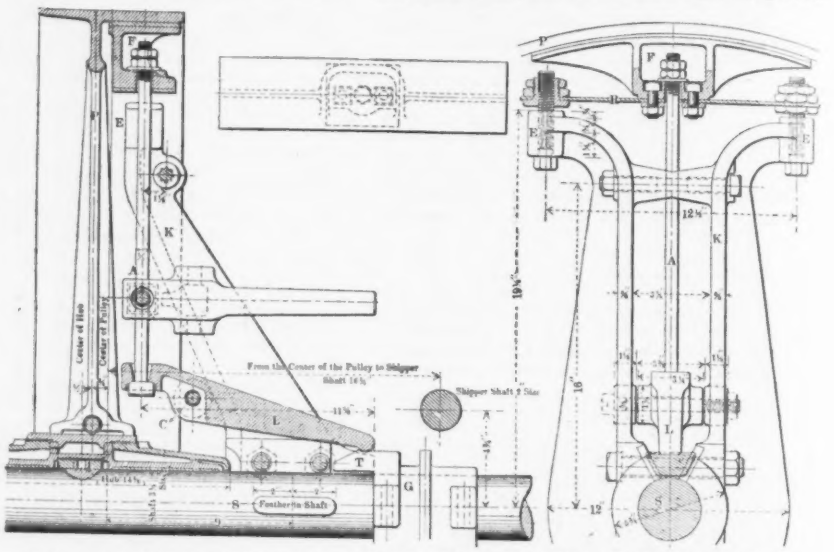


FIG. 8. FRICTION DRIVE OF A CENTRIFUGAL MACHINE (WESTON SPINDLE).

Where pack animals or wagons are available, of course, a much greater variety of food will be usually taken, and food of greater bulk, although of no greater nutritive value, may be used.

In our issue of April 27, 1899, will be found a list of camp supplies for Northern Pacific R. R. surveying parties. We find upon study of this list that, omitting spices and coffee, each man was provided with 5 lbs. of solid food per day, which is at least one-third more than hard-working men need even of such food as was taken along. Weight alone is no criterion of food value, of course, but a study of the chemical ingredients of the foods on the Northern Pacific survey list shows that enough nitrogenous matter, fats, starch and sugar are contained to feed one man 590 days, if we accept the data of Dr. Pavy (Encyclopedia Brittanica). Dr. Pavy says that a laborer requires daily 0.25 lb. nitrogenous matter, 0.10 lbs. fats, and 1.18 lbs. carbo-hydrates (sugar and starch). The Northern Pacific survey list supplies about 135 lbs. of nitrogenous, 175 lbs. of fats and 750 lbs. of starch and sugar. The prospectors' list above given supplies daily 0.23 lb. nitrogenous food, 0.30 lb. fat, and 1.30 lbs. starch and sugar, which, it will be seen, does not differ materially from Dr. Pavy's recommendations except in providing more fat and a little more of the carbo-hydrates; yet the list was not scientifically selected beforehand, but guessed at at first, and subsequently replenished where deficient.

Not the least noteworthy is the fact that a prospector's food need not, and usually does not, cost more than $6 a month, or 20 cts. a day where normal prices prevail, as they now do in most parts of the West.

Those who scoff at popular magazine articles on "How to Live on Twenty-five Cents a Day" have evidently never camped out, for extravagant indeed is the prospector who spends as much as "two bits" (25 cts.) a day on food alone—"liquid refreshments" not included.

THE NEW YORK MEETING OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

The opening session of the 46th meeting of the American Society of Mechanical Engineers was held at the Society's house on the evening of Dec. 2. As the President of the Society, Mr. Edwin H. Reynolds, was unable to be present on account of illness, a paper on "A Rational Solution of the Problem of Weights and Measures" was read by Prof. Sidney A. Reeve. In the paper the duodecimal system was advocated, but it called forth little discussion.

BUSINESS SESSION.

The second session, Wednesday morning, Dec. 3, which was held at the Sturtevant House, was devoted almost entirely to business.

A committee on Standard Screw Threads for Screws Less than One-quarter Inch was appointed as follows: Mr. Wilfred Lewis, Mr. Geo. B. Stetson, Mr. C. C. Tyler and Mr. A. H. Riddell. As members of the Board of Award of the Fritz Medal there were named Prof. G. Lanza, Prof. J. E. Sweet, Mr. S. T. Wellman, and Mr. Robert W. Hunt. This board, our readers may recall, is to consist of 16 members, four appointed from each of the four principal national engineering societies of America.

The tellers reported that 50 members, 10 Associates and 33 Juniors had been elected.

At the meeting held at Boston last May a committee was appointed to revise the Society's Constitution or "Rules" as it is called. The committee consisted of Messrs. C. W. Hunt, Jesse M. Smith and Henry R. Towne. It presented a preliminary report enumerating a number of features which it is proposed to embody in the new constitution, and upon which the opinion of the members was asked. The question which aroused the most interest and debate was whether or not Juniors should be permitted to remain in the Society as Juniors after attaining the age of 30; after having had experience sufficient to entitle them to Associate or full membership. After much debate a resolution, presented by Mr. George S. Morison, was passed, voicing the sentiment of the members present to the effect that Juniors hereafter elected shall be dropped from the Society's rolls at the age of 30, unless they shall be promoted to one of the higher grades of membership. The members also expressed themselves as being opposed to the plan suggested by Mr. Jesse M. Smith, of successively increasing the annual dues of the Juniors by one dollar a year until the fee equals that of Associates.

Mr. Charles Whiting Baker had given notice at the meeting a year ago and also at the last Boston meeting, of an amendment to the Constitution establishing the letter ballot upon any changes in the Constitution.

Under the present Constitution only those members present at a meeting can vote upon changes in the Constitution, and members not present can only vote by proxy.

The resolution offered was as follows:

> Strike out Article XLV. Substitute in its place the following:
>
> At any regular meeting of the Society any member may propose in writing an amendment to these Rules, a copy of such amendment having been filed with the Council at least ten days before the opening of said meeting. Such amendment shall be taken up by the Society at a following session of the same meeting, and shall be subject to discussion and amendment and to final acceptance or rejection by a majority vote of the members present and voting. If it is finally accepted, it shall be submitted to a letter-ballot of the entire voting membership of the Society; such ballots to be sent out at the same time as the next succeeding ballot for the election of members. A majority of the ballots cast shall adopt or reject the amendment.

The Committee on Rules also reported an amendment designed to establish the letter ballot on changes in the Constitution, but combining with it a system of voting by proxy, and containing other features which were criticised in the debate which took place. Mr. Towne, of the committee, withdrew his support from the committee's amendment and offered a new amendment similar in most of its features to Mr. Baker's. After an extended debate, however, Mr. Baker's amendment, as printed above, was adopted by a vote of 152 to 40.

The tellers announced the election of the following officers to serve for the ensuing year:

President, James M. Dodge; Vice-Presidents, F. H. Daniels, James Christie and John R. Freeman; Managers, R. C. McKinney, S. S. Webber, and Newell Sanders; Treasurer, Wm. H. Wiley.

There were 549 votes cast out of a total voting membership of about 2,000. The only contested position was that of treasurer. Mr. Wm. H. Wiley receiving 264 votes and Mr. F. H. Stillman 151, while no choice was expressed by the remaining 130 voters.

The report of the Committee on Standard Engine Trials was read, and in it one very valuable suggestion was made relative to the necessity of specifying exactly what a test for engine efficiency shall include. In discussing this report Mr. William Kent stated that in testing an engine recently he found that 12.8 lbs. of steam were required per I. HP. for the engine alone; while the same engine with accessories required 14 lbs. per I. HP.; 13 lbs. per I. HP. had been specified as the limit, and the question then arose as what constituted the "engine."

THE METRIC SYSTEM.

After the regular business had been disposed of the first paper read was "The Metric System," by Mr. F. A. Halsey, Assoc. Editor "American Machinist." An abstract of this paper appears elsewhere in this issue, and need not be reviewed here, except to say that Mr. Halsey strongly opposed the adoption of the metric system, urging that even in France after more than a century, and in Germany after nearly 30 years of use it is not in exclusive use. He believes that the history of its use in the United States would be similar.

In the discussion that followed the reading of this paper a large number of letters from members of the Society were read, the verdict being about four to one against the introduction of the metric system. A number of letters from officers of large manufacturing companies were all against the metric system, one firm stating that it would cost them $130,000 to replace their present taps, dies, etc., with parts graduated in millimeters. Many of the officers went so far as to say that they would not bid at all on machines of metric dimensions.

Mr. Stratton, Director of the National Bureau of Standards, replied to some of the arguments of Mr. Halsey. Mr. Stratton said that the existence of English units in reports of consuls in metric countries proved nothing except that the consuls had translated the metric units for the benefit of Americans. He read a statement of Andrew Carnegie favoring the metric system.

Hon. J. H. Southard, Chairman of the House (Congress) Committee on Coinage, Weights and Measures, was requested by the chair to explain the bill pending, relative to the adoption of the metric system by the departments of the Government.

Mr. Southard said that the bill provides that in all departments of the Government (except in the survey of the public lands) the metric system shall be used exclusively after Jan. 1, 1904; and that after Jan. 1, 1907, the metric units shall be the legal standard in the United States. This last clause incidentally has been the one most opposed by members of the Am. Soc. M. E. He explained that it did not make the metric system compulsory, reading the opinion of the Attorney-General to that effect; and he further stated that no law can be compulsory that does not provide a punishment for its infraction. He stoutly maintained that the bill was harmless, and was in effect a "try-it-on-the-dog" measure; so that if it works well in governmental affairs it would be likely to be adopted freely by the rest of the country. He urged that our expanding foreign trade makes it imperative that we use an international or universal system like the metric.

Mr. F. J. Miller, editor "American Machinist," made a strong plea for the metric system. He maintained that it was not necessary or desirable to make a sudden change, but that new machines and tools might be gradually introduced with metric dimensions. Willans & Robinson, of Rugby, England, were cited as a firm who had found it a paying proposition to use metric tools and parts. Lord Kelvin and Sir Benj. Baker were cited as in favor of the system; likewise Mr. C. L. Libbey and Mr. H. B. Bartlett, both Americans, who have had four years' experience in German shops.

Mr. Gus. C. Henning strongly urged the adoption of the metric system. He had never seen anything but the meter used in French shops, and contradicted Mr. Halsey's testimony to the contrary.

It may seem from the discussion, as above outlined, that the sentiment of most of the members of the Society was favorable to the metric system. This is hardly so. Most of the members seemed to feel that Mr. Halsey had put their own view strongly enough, and that no more need be said on that side.

The Society's Committee on the Metric System then presented a report favoring the binary or English system of weights and measures, and expressing the opinion that the metric system would not live the century out in any country. The report closed with the statement that mechanical engineers are the only competent judges of what units are best for their own work, and recommended the adoption of a resolution, expressing the sense of the Society that the bill now before Congress "conceived in ignorance is absolutely absurd."

Mr. Henning moved that the report of the committee be laid upon the table, stating that the committee had failed to present facts, but had merely formulated its own opinions.

The motion was carried.

It was then moved and carried by a vote of 34 to 29 that the Council be instructed to confer with other engineering and scientific societies relative to appointing a committee composed of three members from each society to investigate the question of adopting the metric system.

Under this heading, although presented at a later session on Friday, comes a resolution offered by Mr. William Kent to the effect that the Secretary be instructed to send to each member of the Society a blank upon which his individual opinion may be recorded relative to the metric system in general and to the particular bill now before Congress.

The resolution was adopted.

OTHER PAPERS READ AT WEDNESDAY SESSIONS.

Prof. S. A. Reeve presented a short paper entitled "Entropy Analysis of the Otto Cycle." Mr. J. C. Riley followed with a paper on "Apparatus for Obtaining a Continuous Record of the Position of an Engine Governor."

Mr. W. J. Slichter's paper on "Fly Wheel Capacity for Engine-Driven Alternators" will be printed in a subsequent issue; and Mr. William Kent's paper on "Heat Resistance the Reciprocal of Heat Conductivity" was given in full in our last issue.

PAPERS READ AT THE THURSDAY SESSION

"A Forty-four Foot Pit Lathe," by Mr. J. M. Barnay; "Finer Screw Threads," by Mr. Charles T. Porter; "A Surveying Instrument in the Machine Shop," by Mr. C. C. Tyler; "Gift Propositions for Paying Workmen," by Mr. Frank Richards; and "Deflection of Beams by Graphics," by Mr. W. Trinks, were the five papers presented Thursday morning.

Of these Mr. Tyler's and Mr. Richard's papers brought out the most discussion.

It appeared from the discussion of the former paper that many members of the Society had used transits in lining up shafting, and those that had done so were strongly in favor of the transit instead of the carpenter's spirit level, which is extremely inaccurate besides being slow. It should be observed, however, that Mr. Tyler's use of a surveying instrument is a novel use, differing radically from the use of a transit for lining up shafting. The instrument used by Mr. Tyler is for facilitating the accurate dressing and drilling of large pieces of metal where portable tools are used.

Mr. Richards' paper on "Gift Propositions for Paying Workmen" was severely criticised by many members in the discussion that followed its reading. In brief, Mr. Richards does not believe in any bonus or piece work system, but his method of reasoning was entirely deductive, that is not based upon actual trial of both systems on the same body of workmen; but based upon *a priori* reasoning as to what should happen under assumed conditions. He voiced the sentiment of

a few manufacturers, but not of any who have given all systems a long trial.

One of the speakers emphasized the point that when a bonus or premium system with a given schedule of prices is once adopted, no cuts should be made for at least a year thereafter; for if cuts are made the workmen soon cease to do their best, knowing that in the end they will be earning no amount corresponding to their increased exertion.

PAPERS READ AT THE FRIDAY SESSION.

The papers presented at the last, or Friday, session were as follows: "Rotary Pumps," by Mr. J. T. Wilkin; "Filing System for Office Use," by Mr. H. M. Lane; "Analysis of Commercial Value of Horse Power per Annum," by Mr. A. F. Nagle; "Centrifugal Machines," by Mr. B. Viola, and "Oil Testing Machine and Results," by Prof. A. Kingsbury.

Two of these papers appear elsewhere in this issue, those of Mr. Wilkin and Mr. Viola.

In the discussion of Mr. Nagle's paper on the value of water power, Mr. Geo. I. Rockwood said that the substance of the paper had been previously presented in a paper by Mr. Main. Mr. Rockwood observed that there are three classes of witnesses in every suit wherein the value of water power is involved; first, the lawyer who can talk nothing but "easements"; second, the engineer who, assuming certain data of flow, deduces the horse power available; and third, the business-man who cares nothing as to how much power is available, but how much is actually in use, and what it would cost to buy the same kind of power. Mr. Rockwood described a patented water-wheel meter, designed by himself, and Mr. Charles M. Allen, and used with good results in determining the water actually used by a water wheel. The meter is attached to the shaft of the water wheel and integrates the quantity of water used.

Prof. Thurston; in a written discussion of Prof. Kingsbury's paper on "Oil Testing," called attention to the fact that the curves of coefficients given by Prof. Kingsbury are hyperbolic in form. He said, also, that he had never before seen so low a coefficient of friction obtained in any tests.

TOPICAL DISCUSSIONS.

The session closed with discussions on Smoke Consumption, Elastic Resistance, Oil Burners, Oil Separation from Steam and Oil-Tempering of Steel.

By far the most valuable point brought out in these discussions was one relating to preserving the efficiency of an oil separator.

Mr. D. J. Lewis, Jr., said that to begin with, the steam from which oil is to be separated should be passed just as soon as possible into the separator. In his early experience he had found that the cast-iron baffle-plates of the separator worked admirably for a few weeks, then they suddenly dropped off in efficiency. After considerable investigation he found the reason to be that the oil having once soaked into the pores of the iron baffle-plates greatly reduces their efficiency. To overcome this he now boils the plates for ten hours in a soda and potash solution, at the end of which they are as good as new. This cleaning is necessary once every four weeks with ordinary engines, once every two weeks with the Westinghouse engine.

In the discussion of oil burners several members stated what now appears to be quite generally believed, that the type of burner is not so material as has been supposed, but that the furnace in which the burners are used is the really important factor of success or failure. Prof. F. N. Willson said that the increased rates of fire insurance where oil is used frequently constitutes a deciding factor. It was stated by another member that the air used to burn the oil and the oil should both be metered. Where this is done less than 1% of the fuel is required to spray the oil, where this is not done, as much as 4% may be required.

EXCURSIONS AND RECEPTION.

The opening session, Tuesday evening, at the Society parlors, on 31st St., was a short one, followed by a "smoker." After the morning session on Wednesday at the Sturtevant House, a luncheon was served. Thursday afternoon was devoted to visiting the stations of the Interurban Street Railway Co., at 93d St., the Manhattan Elevated Co., at 74th St., and the Waterside Station of the New York Edison Co., at 38th St. The Interurban Street Railway Co. acted as host, furnishing transportation tickets and guides.

On Thursday evening a reception of members and guests by the Acting President and President-elect was given. The reception was at Sherry's, and was a most enjoyable feature, dancing and refreshments forming part of the entertainment provided.

The next meeting of the Society will be held at Saratoga next summer.

THE IMPROVEMENT OF INTERIOR LIGHTING.

Within the past few years great developments have been made in lamps and other appliances for interior lighting, and there is a very liberal use of such improved lamps in modern buildings. Comparatively little progress has been made, however, in the art of lighting, or the proper arrangement of lamps so as to give the best and most effective distribution of light, while at the same time effecting an economy in the light, and consequently of the power required for its generation. In very many cases there is too much light, owing to the rather prevalent idea that quantity is the chief consideration, and that as more lamps are used the better will be the lighting. This of course involves an unnecessary use of and consequent expense for the electric current, gas, or other source of light. The proper system of lighting to be used in any individual case must depend largely upon the special or local conditions. Thus, the use of concealed lamps with light diffused by means of reflectors and reflecting surfaces is not of general application, and where either concealed or exposed lights are used the form and uses of the room must be taken into consideration. For instance, the requirements for a drafting room are very different from those for a picture gallery, a lecture hall, or a church.

At a meeting of the Western Society of Engineers, in May, 1900, the late Prof. J. B. Johnson, in describing the new engineering building for the University of Wisconsin referred to the system of lighting the drafting rooms and auditorium by means of concealed lamps with opaque reflectors dispersing the light uniformly over dead white ceilings, the reflection from which served to light the rooms. This system, which has been adopted in a number of cases, was designed to do away with strong glaring lights. Prof. Johnson took occasion to style as "barbarous" the system of lighting then in use in the society's lecture room; this consisted of ceiling groups of exposed incandescent lamps with clear glass bulbs, and as the room is quite low the effect was dazzling and annoying. In this particular case the lighting has been improved by enclosing the groups of lights in large "holophane" globes, the special feature of which is that they are formed with lenses to break up and distribute the light, giving an even diffused light without shadows or bright spots. Various forms of ribbed globes are in the market, but the special feature of the "holophanes" is that the section of the prisms or lenses is carefully designed on scientific principles, and the globes are formed in accurately cut molds. The result of this care in the design and manufacture is that there is a maximum diffusion of light, with a minimum of absorption in the glass. The whole globe is luminous, but the source of light itself is not visible, while the direction in which the light is thrown depends on the shaping of the prisms.

A notable feature of the method of planning a lighting scheme on the basis of the scientific calculation of illumination, is that the requirements can be accurately ascertained beforehand, and the proper arrangement of lamps and distribution of light calculated to meet these requirements, the results obtained conforming very closely to those determined in advance. An interesting example of the practical application of the scientific principles of artificial lighting to determine the best and most efficient arrangement under given conditions is afforded by the new Sculpture Hall at the Art Institute of Chicago. The architects are Shepley, Rutan & Coolidge, of Chicago, and the lighting scheme was worked out by the V. R. Lansingh Co., illuminating and electrical engineers, of Chicago, which compa[illegible] making a specialty of this class of work. [illegible] hall is 212 ft. long, 62 ft. wide, and 33 ft. [illegible] with a row of windows high up in the east [illegible] (fronting Lake Michigan). The ceiling is pa[illegible] so that the location of the lights must be e[illegible] on the beams or in the centers of the panels. It was decided in the first place to use group[illegible] incandescent lamps enclosed in "holopha[illegible] spheres, and to use lamps of sufficient inte[illegible] to avoid the necessity of using too grea[illegible] number.

As the hall is to be used almost entirely [illegible] sculpture and large architectural pieces, the ligh[illegible] ing of the walls and vertical planes was of m[illegible] importance than that of the horizontal pla[illegible] and the calculations were based therefore on the vertical lighting. The photometric curve of [illegible] globe with the number of lights decided upon was first obtained, and the vertical distribution curve was at once obtained from this. A certain arrangement or mesh work of lights was then selected for trial, and the resultant illumination was obtained, taking into account the reflection from the walls. The height of the lamps was governed by the fact that a balcony runs along the entire length of one side of the room, and precludes the lowering of the lights below the level of the eye of a spectator on the balcony. The scheme of arrangement of the lights was changed several times in order to get the best resultant illumination, so that the lights as finally installed would give a very uniform illumination on the side walls and on vertical planes. After this scheme had been finally determined upon, however, the authorities of the Art Institute decided to install arc lights for the present, on account of their lower first cost, but it is intended later to adopt the proposed system of grouped incandescent lights in "holophane" spheres, as above described.

In this connection we give the following abstract of a paper by Prof. Wm. L. Smith, on "A Study of Certain Shades and Globes for Electric Lights as Used in Interior Illumination." This paper was published in the Technology Quarterly, March, 1902:

It is only in very rare cases that it is advisable to use modern light sources, as Welsbach mantles, acetylene gas, incandescent or arc lamps, unaccompanied by some form of diffusing shade or globe, for most frequently the source will come somewhat within the line of vision. In this case the intrinsic brilliancy must be cut down. The value of the candle-power emitted per unit of area of light-giving surface is very high. Thus the open arc may give over 25,000 c. p. per sq. in., the incandescent lamp may range from 100 to 200, acetylene gas ranges from 75 to 125, while the Welsbach mantle will vary from 20 to 25. Of the older light sources, the flat flame of gas gives from 4 to 8; the oil lamp, from 3 to 8 (both varying widely), and the candle is lower still. It is safe to say that the intrinsic brilliancy should never rise above 5 c. p. per sq. in., and I prefer to keep it rather lower if possible.

Thus it will be seen readily that the use of some form of diffusing shade is necessary in the great majority of cases, in order that the light may appear to radiate from a much larger surface than is the case with the bare lamp, and thus the intrinsic brilliancy be properly reduced. But the shade ought to do more than this, it should aid us from the point of view of illumination as distinct from lighting, and it is just this distinction which the great majority of persons fail to take into account.

For instance, let us consider a drafting room. Suppose we hang lights on pendant cords over each drawing table; the illumination of the boards will be strong and bright, yet the room may be very badly lighted. If the lamps are fitted with conical green paper or tin shades the whole upper part of the room will be in gloom and the worker's eyes strained as he raises them from his work and then drops them again. If the lights are bare, the conditions may be as bad, if not worse; since, if the lamps are high, it will be difficult to get light enough at the proper angle on the board; and if low, they may easily come within the range of vision. In either case the workman will find that on raising his eyes from his work they are strained, just as when the shades were used. In the first case the iris dilated to accommodate itself to the gloom of the room as compared to the board, in the second case it contracted to accommodate itself to the presence of the small, bright light sources; so that the alternate opening and closing will finally result in serious strain, and may do irreparable damage. We get, in other words, good illumination but very bad lighting.

Now, suppose this room to be lighted by concealed lamps of high power, their light being thrown on to a white diffusing surface, as a slightly arched ceiling and whitened walls; the room will be excellently lighted, but

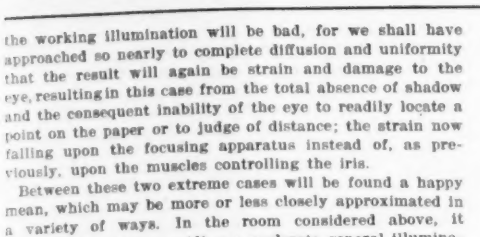
the working illumination will be bad, for we shall have approached so nearly to complete diffusion and uniformity that the result will again be strain and damage to the eye, resulting in this case from the total absence of shadow and the consequent inability of the eye to readily locate a point on the paper or to judge of distance; the strain now falling upon the focusing apparatus instead of, as previously, upon the muscles controlling the iris.

Between these two extreme cases will be found a happy mean, which may be more or less closely approximated in a variety of ways. In the room considered above, it would be found in providing a moderate general illumination by the hidden lights, and fitting each table with a small, thoroughly shaded lamp, flexibly supported, so that its rays could be directed at any desired angle upon any desired portion of the work. Such a lay-out, however, would prove decidedly expensive, and an approximation to the result might be made by the use of larger lamps raised high and fitted with globes which would cut down the intrinsic brilliancy properly, and at the same time direct the light downward, so as to give sufficient illumination.

Accordingly, it is of great importance to be able to determine beforehand just what a given arrangement is going to give in the way of illuminating effects. In some cases one can say offhand that the results will be thoroughly bad. Thus, if a globe with the top half opal and the lower half clear glass, cut with a many-rayed star, is used, the result will be unsatisfactory for many purposes, because the globe will produce very marked striations on a surface below. Again, take the case of the turnip type of incandescent lamp, with the upper half silvered. If the bottom half is clear glass, the light downward will be very intense, but the illuminated surfaces will be crossed and cut up by caustics and striations of great prominence. If, on the other hand, the lower half be frosted, the light will be much reduced (which does no great harm, because almost everyone just now is carried away by the delusion that the more powerful the illumination the better he can see, than which there is no greater error), but the illuminated surface will show no trace of striations and the result will be good.

In the cases of the great majority of other globes and shades, it is very difficult to tell just what will be the effect, even if the distribution in the mean vertical plane (found by spinning the combination) is known. Globes of the same pattern frequently vary widely among themselves, and the distribution of a given globe varies with the azimuth, so that it is altogether too laborious to attempt a calculation, with the probability in view that it will prove fallacious in the end.

It is herein, in my opinion, that one of the greatest advantages of the "holophane" glass is to be found. The efficiency of the globes is excellent, the light can be thrown practically in any desired direction, and the diffusing action is practically perfect. I think that they also excel in the uniformity existing among individual globes



ENG. NEWS.

Diagram for Determining the Illumination of a Surface.

of the same type, and in the precision with which they allow the determination beforehand of the results to be obtained—such precision, of course, being an important indication of scientifically correct design and careful manufacture.

METHOD OF DETERMINING THE ILLUMINATION ON A SURFACE.

Given a lamp having a definite distribution curve, and situated at a definite height above a horizontal plane, to determine the illumination at any point of the plane:

In the accompanying diagram let O be the center of the lamp having the distribution curve, ABE, and let MX′ be the surface, drawn at a vertical distance OM, below OX, such that K. OM = the distance in feet of the surface below the lamp, K being the equating constant, while the candle power along any radius, as OP, is given by K′. OB, OB being measured in the same units as is OM—say in centimeters.

The intensity of illumination at the point P in the horizontal plane will be:

$$e = \frac{K' \cdot OB}{(K \cdot OP)^2} \cos QPO.$$

Now, let us lay off OP′ = OP, join B and P′, and through M draw parallel to BP′, giving us point R. Connect R and P′, and through M draw a parallel to RP′ and we obtain a point S, and we have:

$$OS = OB \left(\frac{OM}{OP}\right)^2.$$

If through S we draw parallel to OX until we reach PQ at F, we shall have:

$$QF = OS \cos QPO = OB \left(\frac{OM}{OP}\right)^3 \cos QPO,$$

and it follows that

$$e = \frac{K'}{(K \cdot OM)^2} QF = \frac{K'}{h^2} QF,$$

h being the true height of the lamp above the plane in feet.

Continuing this process with successive radii, we obtain a curve, as 1, 2, F, E, having O as the origin, OX and OM as axes of abscissæ and ordinates respectively, such that the abscissa of any point multiplied by K gives the distance of the point from the foot of the perpendicular through the axis of the lamp, and the ordinate multiplied by K'/h^2 gives the illumination at the point in candle-feet. It is obvious that, if a given type of lamp or globe always gives the same distribution curve, that the above construction gives a plot which will be suitable for any candle-power and any height of lamp, the values of the equating constants K and K′ being changed to correspond. If a point receives light from more than one source, it is sufficient to sum up the illuminations received from the several sources.

In the figure, if K = 1, i. e., if 1 cm. = 1 ft. and K′ = 5, i. e., if 1 cm. = 5 candle-power, then the height of the lamp will be 6.5 ft. above the plane, the illumination at the point P, distant 5.4 ft. from the foot of the perpendicular, will be:

$$e = \frac{K'}{h^2} Q F = \frac{5}{(6.5)^2} (1.8) = 0.21 \text{ candle-feet.}$$

APPLICATION OF THE METHOD.

A case to which I have recently applied this method, and which furnishes a good example of its powers, is that of the new meeting house of the First Parish in Concord, Mass. The first step in the work was to determine the total candle-power required in the auditorium. This has, allowing for the space occupied by the galleries, organ, etc., approximately 82,000 cu. ft., requiring, on the basis of 0.02 c. p. per cu. ft., a total of 1,640 c. p. It was intended to use 20 8-in. "holophane" balls for pendant use, 34 6½-in. balls for upright use, and one 16-in. sphere for pendant use. The first and third have an absorption of 13.8%, while that of the 6½-in. balls is 12.1%. Allowing for the relative quantities of the several globes, this gave a mean percentage of 12.7, and, accordingly, the candle-power required would be increased to 1,848, while the amount actually used was 1,862, as this divided up better, being at the same time on the safe side.

The auditorium is finished in a delicate blue tint on float-scoured plastering. The ceiling is slightly curved, finished to a light cream, the cornice white, and all woodwork and trimmings white. Behind the pulpit the finish is gold leaf, with a matt surface and white trimmings, so that the only dark portions are the blue carpet, the California redwood pews, and the mahogany pulpit and organ case at opposite ends of the auditorium. Some careful measurements upon finish of this nature indicated that one might safely count on an increase of about 75% over the calculated illumination due to diffuse reflection.

A surface upon which to lay out the illumination was chosen at 4 ft. above the floor, that being about the average height of hymn books during singing by the congregation. Several typical points were now chosen, the lights affecting these carefully located on the building plans (though no light more than 50 ft. away was considered), the distances measured, and the illumination determined. The location of the lights was then changed somewhat and the calculation repeated, the location finally chosen being that which on the average turned out best; it being decided to keep, so far as possible, between the values of 1.0 and 1.5 candle-feet.

At one of the observation stations, the illumination summed up to 0.72 candle-foot. Increase this by 75%, and it is 1.26 candle-feet, a number fairly within our limits. It was found afterward by measurement with a Leonhard Weber portable photometer that at this station the actual illumination was 1.24 candle-feet, a difference of less than 2%.

When this exact location for the lights had been determined, large scale plots of the illumination curves were made, and the illumination at 75 stations was calculated, to be sure that no serious discrepancies had crept in. These stations were all on one side of the auditorium, it being assumed that the other side would be symmetrical with the first.

In another case a hall was to be lighted, the location of the lights being fixed by the wiring, which was already in place; but it was desired to improve the illumination, which was rather poor; due to the facts, first, that the lamps, which originally were simply frosted bulbs, did not distribute in the proper manner; and, second, that the candle-power per cubic foot was low. The hall is approximately 48 × 60 ft., and 24 ft. high; it is used for public meetings and entertainments, etc. The lamps were arranged in a line around the sides of the hall, on the ceiling close to the walls, and in the center of the ceiling was placed a circle of 12 lights, the lamps hanging about 3 ft. down. Under these conditions there was a marked bright spot in the center, and the illumination fell off gradually toward the walls, in no place being over 0.85 candle-foot, and the average being about 0.65 candle-foot. The change made was to replace the side lights by clear bulbs; to make the central ring double the diameter of the original (or 18 ft.), and to put clear glass, 50-c. p. lamps there. This done, the side lamps were then fitted alternately with "holophane" stalactites, throwing the maximum light off at 45°, and throwing it directly downward, while the central ring was fitted with dishes of similarly alternate action. The result was that the illumination was raised to a mean value of 2.00 candle-feet, the maximum found (out of 75 equi-distant points) being 2.12, and the minimum being 1.92.

AN ELEVATED RAILWAY AT ST. LOUIS, MO., is proposed as a means of affording additional transportation facilities for the Louisiana Purchase Exhibition, and two projects have been submitted to the city council. One of these is backed by Mr. J. D. Housman, who controls some of the suburban electric roads; he offers the city $50,000 for the franchise, and 5% of the annual profits after the expiration of 50 years. The other project is that of the St. Louis Elevated Ry. Co., composed of Jordan W. Lambert, M. L. J. Lambert and Henry W. Bond. This company makes no offer of any return for the valuable privileges to be granted, but leaves this for future arrangement with the city. Both projects provide for a steel structure, with 16-ft. headway, and carrying pneumatic tubes, telegraph and telephone cables. They also both provide for electricty or compressed air as the motive power.

A PUBLIC CABLEWAY IN ARGENTINE is to be constructed, according to "La Ingenieria," of Buenos Aires. The route is from the town of Chilecito, province of Rioja, in northwestern Argentine, to the mines of La Mejicana, about 22 miles north. The two termini are about 11,000 ft. apart vertically; the terminus at La Mejicana is at an elevation of 15,200 ft. above sea level. The cableway will therefore be on an average gradient of something over 10%, and it will probably be operated as a gravity line. The alinement is nearly a straight line, but lies along a very rough and inhospitable mountain slope. It is expected that only about nine months' traffic per year will be realized. The cableway is being built by the Department of Public Works of Argentine; Bleichert & Co., of Leipzig, Germany, have the contract for the construction work and machinery.

THE 25TH ANNIVERSARY BANQUET OF THE ENGINEERS' CLUB OF PHILADELPHIA.

On Saturday evening, Dec. 6, the 25th anniversary of the founding of the Engineers' Club of Philadelphia was celebrated by the club at a dinner held in the great banquet hall of the Union League Club. Those in attendance at the dinner nembered nearly 300, including representatives of a number of other engineering societies, and many engineers from other cities.

The post-prandial proceedings were opened by the President of the club, Mr. Henry J. Hartley, who delegated to Mr. Jas. M. Dodge, the chairman of the Executive Committee which had charge of the preparations for the dinner, the duties of toastmaster. The list of formal toasts was as follows:

"Welcome to Our Guests," Mr. L. Y. Schermerhorn; "Our Army Engineers," General William P. Craighill, U. S. A.; "Our Navy Engineers," Admiral George W. Melville, U. S. N.; "Our Honorary Members," Mr. James Christie; "The Engineer of the 20th Century," Mr. Chas. F. Scott; "Commerce," Mr. Robert W. Lesley; "Engineering and Our Kindred Societies," Mr. John Birkinbine; "Our University," Prof. Arthur W. Goodspeed; "Our Founders," Mr. Wilfred Lewis; "The Technical Press," Mr. John C. Trautwine, Jr.; "The Union League," Mr. Peter Boyd.

Mr. Schermerhorn, after cordially welcoming the guests of the evening, referred to the early history of the club as follows:

During the Centennial Exposition, held in this city in 1876, the American Society of Civil Engineers and the American Institute of Mining Engineers established headquarters in Philadelphia for the convenience of American and foreign engineers visiting the Exposition, and throughout its continuance an open house was kept at these headquarters and weekly meetings were held on Thursday evenings.

The remembrance of the pleasure and success of these meetings led a few of our local engineers to organize The Engineers' Club of Philadelphia, on December 17, 1877, with a charter of membership of 23, of which Messrs. Chas. E. Billin, Wilfred Lewis, M. R. Muckle, Jr., and Wm. G.Neilson are among its present members.

Since the date of our organization the Club has steadily developed, and it now enters upon the second quarter century of its existence with a membership of nearly 500 and a list of honorary members of world-wide reputation.

Gen. Craighill, who was to have responded to the toast "Our Army Engineers," was unable to be present, and the response was made by Mr.

Oberlin Smith, Past-President of the American Society of Mechanical Engineers.

Admiral Melville when he rose to respond to the toast "Our Navy Engineers" received a remarkable ovation from the assembled company. In concluding his remarks Admiral Melville said:

Our new Navy has been hammered out by the combined efforts of the whole engineering world of the United States. Our naval engineers would be the last ones to take to themselves the sum total of credit for the success of our ships. They will always expect and appreciate that co-operation and sympathy of their brother engineers in civil life which have contributed so much to the success of their previous efforts. And, gentlemen, it is only in this way, by the concentrated energies and united labors of the entire engineering profession, in every important project, that we can carry forward the greatness and grandeur of the nation.

Mr. Jas. Christie in toasting the Club's honorary members, read a number of letters from honorary members who were unable to be present, including among others, the veteran, Chas, H. Haswell. Short speeches were then made by two of the honorary members, who were present at the dinner, Mr. John Fritz and Dr. Coleman Sellers.

Following this came the most notable address of the evening, made in response to the toast "The Engineer of the 20th Century," by Mr. Chas. F. Scott, President of the American Institute of Electrical Engineers, and representing also at the banquet the Engineers' Society of Western Pennsylvania.

Mr. Scott showed that notwithstanding the multitude of applications of electricity it does not stand alone but acts as a servant to transmit the forces and do the work of other departments of engineering; he then took for his theme the subject of coöperation among engineers, and continued as follows:

The great discovery of the 19th century was co-operation—the effectiveness of concentration. Compare the old days of the hand loom in the home, of the shoemaker at his bench, of the individual oil well and coal mine, of the small railroad and of the small factory—compare these with modern methods, with their unbounded possibilities—possibilities of good and possibilities of evil. Of good, because the engineer has provided the means for doing the world's work more efficiently; of evil, because the social, the industrial, the commercial systems have not kept pace with the advance made by the engineer, for they are tainted by injustice and by selfishness.

The tendencies of the 19th century projected into the future reveal, in dim outline, at least, the engineer of the 20th century. He is to become a greater factor in adjusting and operating the intricate mechanism of a new civilization. He is to deal with large affairs in a large way. He is to be closely related to every department of modern life.

He will be advanced to administrative positions, for which his knowledge and his training peculiarly fit him. At the head of the Pennsylvania Railroad, directing its vast affairs in the present and planning to meet the demands of the future, is an engineer surrounded by engineers, President Cassatt. At the head of the interests with which I Am connected is a man successful as an organizer and manager and financier, a genius in his foresight, an engineer, George Westinghouse.

Sound judgment, breadth of view, integrity, character, the ability to understand and to control men as well as matter, to direct human forces as well as physical forces are essential to the engineer of the future.

Beside the new relations to others there will be new relations of engineers among themselves. All that I have said so far emphasizes what we all know, namely, that the several branches of engineering are interdependent and corelated. Take a single great work, the extension of the Pennsylvania Railroad into New York city, and name an important branch of enginering which is not essential to this undertaking.

The work of the future demands co-operation, not clannishness; unity, not jealousy. Engineers must be specialists; therefore, they must work together. The several branches of the profession have their individual interests, but they have a larger common interest. As we marvel at what the engineer has done, as we attempt to picture what he may do, we realize the far-reaching responsibilities which confront us. Shall we rise to meet them? We gave to the world the steam engine, the steam vessel, the railroad, the telegraph and cable, machinery, industrial processes, the electrical central station—the fundamental requisites which underlie co-operation. Is it not time that we apply to ourselves the great lesson of the last century? What organization stands before the world as representative of the engineering profession? Has the engineer been accorded the recognition and the reward which are his due?

A noted lawyer recently addressed the annual banquet of a local engineers' society containing members of national and international reputation. His remarks were based upon the idea that all engineers were co-ordinate with a common chainman, and they would have been positively insulting except for his air of blissful ignorance. A few years ago a gentleman of eminence in addressing the American Society of Mechanical Engineers advised its members not to join in a machinists' strike!

In what way do engineers present themselves to other professions? In what way do engineers co-operate to advance their own profession by mutual helpfulness? There are national organizations of various kinds—the Civil, the Mining, the Mechanical and the Electrical Engineers, the Architects, the Naval Architects and Marine Engineers, the Engineers in the Army and the Navy, the Chemists, the Electrochemists and others. In general each society knows that the other societies exist, and they are mutually respectful, but there is some suspicion here and there that the others are a little too exclusive or a little too common, or that they are a bit jealous. These are the murmurings of littleness, not of largeness.

The several engineering professions, like the constituent states, have their representative bodies, their legislatures, but why not an Enginering Congress as well? Why not a national representative body to stand for the profession of engineering, to promote a harmonious co-operation which will strengthen each and elevate all?

An incident of the past year is an auspicious omen. Four great societies have co-operated; they have taken a step which will bring recognition to the deserving individual and credit to the engineering profession; they have founded a medal, and at a magnificent dinner they have announced the award of the first John Fritz Medal to John Fritz. But not less significant than the medal itself is the discovery that the societies can work together, and by such co-operation they can accomuplish worthy ends.

In the vision of the future may we not discern a reflection of the John Fritz Medal in the larger life of the 20th century engineer? Methinks I see the outlines of the medal taking the form of a magnificent building, the Capitol of American Engineering. Into this home in the metropolis are gathered the great engineering societies from their scattered lodgings. Here is a great technical library, here are ample assembly halls and comfortable parlors, here are the headquarters of a score of lesser societies, affiliated in their work, but restricted in their scope. I see all over the country innumerable local societies and engineering clubs, no longer isolated, but joined together into one great combination. I see them affiliated with the national bodies—sometimes as local chapters—altogether constituting a great union. There is individual freedom, but general co-operation. The Engineering Congress, representing all the engineering professions and supported by the great Union of Engineering Societies, gives engineers a rank consistent with the importance of their work. It increases the efficiency of the interrelations among engineers and is powerful in advancing the common interests of engineers, and it represents the engineering profession in its relations to other professions, to pure science, to education, to legislation, to public improvements and to the general welfare.

Years ago engineers were individuals of trivial consequence compared with men in the learned professions. Now the technical professions are of recognized importance. But even yet the National Societies of the profession which has made the nineteenth century an era in the world's history, which has provided the means for the production of unmeasured wealth, and which promises yet greater things for the future, have not even homes of their own. But the men who are mastering the power of nature will yet rise in the strength of united effort to meet the increasing responsibilities of the coming years. For it is theirs to build the foundation of the new civilization; it is theirs to establish material prosperity—the underlyng condition for broader, fuller and high life.

The end of engineering is usefulness, the characteristic of America is activity, the modern method is co-operation. As engineers of the 20th century let us be useful, let us be active, let us co-operate.

Following Mr. Scott's address came the toast on "Commerce," responded to by Mr. Robert W. Lesley, Associate Am. Soc. C. E., President of the American Cement Co., in which he showed how completely modern commerce is dependent on the engineer and his works.

Mr. John Birkinbine, Past-President of the American Institute of Mining Engineers and President of the Franklin Institute, responded to the toast "Our Kindred Societies," alluding in a humorous way to the poverty of the Franklin Institute, and also to a time in the Engineers' Club history when its dissolution seemed imminent on account of its financial troubles.

Prof. Arthur Goodspeed, of the chair of Physics at the University of Pennsylvania, gave an account of the phenomenal growth of that institution in recent years, and then came the toast "Our Founders," responded to by Mr. Wilfred Lewis, one of the four charter members who are still actively connected with the club. He gave some interesting notes of the club's early history from which we quote as follows:

Some time in the fall of 1877 a few young men residing mainly in West Philadelphia, of whom I believe our first Secretary, Mr. Chas. Billin, was the leading spirit, conceived the idea of organizing a little group of engineers to meet from month to month at the homes of its members. The suggestion met with a hearty response, and after two or three preliminary meetings had taken place, a formal meeting for organization was called in December at the home of Dr. Coleman Sellers. At this meeting there were 19 attendants who enrolled themselves as members. Prof. L. M. Haupt was chosen President, Coleman Sellers, Jr., Vice-President and Charles E. Billin Secretary, and the Engineers' Club of Philadelphia was thus formally launched. The dues, if any were fixed at this time, were merely nominal, but each member was expected to exercise his privilege of entertaining the Club, and for a time there was quite a rivalry among applicants for that honor. A simple repast, not exceeding the limitations imposed here to-night, was served at each meeting after the reading and discussion of such papers as might be offered, in default of which extracts from leading journals or periodicals were in order, but the social feature was predominant, and a dearth of professional papers was in those days borne with equanimity. But the Club soon doubled in numbers and before all of its founders had an opportunity to extend their hospitality, private houses became inadequate for its accommodation. A room was then rented on West Penn Square, where the Broad Street Station now stands. These modest quarters on the third floor were the arena of many interesting debates, but their very limited dimensions tended to check the social feature and for a time I think the Club ceased to grow. It then found more attractive quarters on Chestnut St., above Broad, and migrated up and down that thoroughfore for several years until it finally acquired sufficient strength to claim a house and home of its own in the comfortable quarters which it now occupies on Girard St.

Of the original 19 members, Mr. Chas. A. Ashburner, who won distinction in his brief career as a geologist, died in 1889. Another, Edward Nichols, who became President of the Brooks Locomotive Works, died in 1892. The others, so far as I know, are still living.

In responding to the toast "The Technical Press," Mr. John C. Trautwine gave another expression of the need for coöperation among engineers. We quote from his remarks as follows:

No one who is at all familiar with the technical press of to-day, and who compares it with that of a quarter-century ago, need be told of the advances which it has made during that time; and yet it has lagged behind the procession in one very important respect. I mean that tendency to consolidation and unification which forms perhaps the most conspicuous, the most remarkable and the most portentous feature of our modern industral life.

While railroad and steamship lines and steel works are rushing together like the kindred rain-drops upon a window pane, the mails and our desks continue to be overburdened with a legion of publications, issued both by technical societies and as business enterprises. The same ground is threshed over and over by competing publications in one and the same narrow field; a given paper is printed and reprinted and abstracted ad nauseum.

Yet some notable effort has been made in the direction of better organization of the technical press; and, in the history of this effort, stands out conspicuously the name of that born organizer, the late Arthur M. Wellington, who was prominently active in all three of the departments of the technical press; first, as author of "The Economic Theory of the Location of Railways," second, as one of the editors of Engineering News, and, last but not least, as one of the founders, if not, indeed, the father, of the Association of Engineering Societies, which, organized in 1881, now numbers 11 societies, including those of Boston, San Francisco, Montana, New Orleans, St. Louis, Cleveland, Detroit and Buffalo, aggregating about 1,600 members, and which gives to the profession a single strong monthly, in place of half a dozen or more struggling annuals or quarterlies.

Happily, the evils arising from the present multiplicity of technical publications promise to work their own cure. Twenty-five years ago many of those here present this evening were school-boys, or less. Twenty-five years hence, most of us old fellows will be out of the running; but I venture to predict that, by that time, there will have arisen an organization which shall comprise, in its publication, not only those of all the important local and sectional engineering societies, but also those of the national societies, and not only those of American, but also those of British societies.

The final toast on the list was an eloquent tribute by Mr. Peter Boyd, of Philadelphia, to the organization which acted as host for the evening—the Union League Club. This concluded the evening's festivities.

Too much can hardly be said in praise of the admirable manner in which all the arrangements for the banquet were made. It reflected great credit on the club and upon those in charge of its work, and the affair will long be remembered as a landmark in its history.

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